UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH AND LOW CONSUMERS OF ARTIFICIAL SWEETENERS: EFFECTS ON APPETITE

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

ABSTRACT

In the natural world, sweetness as a taste is almost always found in association with energy. Associated with energy and the physiological effects of energy, sweetness can exert a number of effects on appetite. With the development of artificial sweeteners however, sweetness and energy can be uncoupled. Uncoupling sweetness and energy, the consumption of artificial sweeteners may have profound effects on appetite and appetite control.

Uncoupling sweetness and energy in the single consumption of artificial sweeteners has previously been widely investigated and is demonstrated in this thesis in Study 1. Sweetness uncoupled from energy can stimulate appetite; an effect which can be explained with reference to the natural sweetness-energy relationship. Uncoupling sweetness and energy in the habitual consumption of artificial sweeteners, remains uninvestigated.

Uncoupling sweetness and energy in habitual high consumers of artificial sweeteners: effects on appetite and appetite control were investigated in this thesis by comparing habitual high consumers of artificially-sweetened beverages with habitual low consumers. Habitual high and low consumers of artificially-sweetened beverages were defined in Study 2. Effects on appetite were investigated in Studies 3, 4, 5, and 6, using highly controlled nutritional challenges: Studies 3 and 4 - responses to sweetness and energy consumed as a drink; Study 5 - responses to sweetness consumed as a meal; Study 6 - responses to sweetness, sweetness intensity and dietary fat consumed as a drink. Effects on appetite and appetite control were investigated in Studies 7 and 8, using self-report questionnaires measuring general eating attitudes and behaviours - Study 7; and using specialized food diaries measuring specific eating behaviours - Study 8.

Throughout this thesis, in female participants, the habitual consumption of artificially-sweetened beverages was found to be associated with high levels of overall appetite (Studies 3, 4, 7 and 8), differing responses to sweetness and energy (Studies 4 and 5), high appetites for sweetness and following sweetness (Studies 3, 5 and 8), and a highly restrained and cognitively controlled eating style (Studies 7 and 8) (including a high consumption of fluids (Studies 3, 4, 5, and 8)). In male participants, the habitual consumption of artificially-sweetened beverages was associated with a highly restrained and cognitively controlled eating style (Studies 7 and 8).

High appetites for and following sweetness were not specific to high consumers of artificially-sweetened beverages and are explained as a result of high preferences for sweetness. A high overall appetite, differing responses to sweetness and energy, and a highly restrained and cognitively controlled eating style can be explained as a result of the habitual uncoupling of sweetness and energy, with reference to the natural sweetness-energy relationship, and may demonstrate persistence and extinction of that relationship. A high overall appetite and a highly restrained and cognitively controlled eating style however can also more appropriately be explained as a result of associations with the deliberate self-selection of a habitual high consumption of artificial sweeteners, and may be unrelated to the uncoupling of sweetness and energy. A high appetite and a highly cognitively controlled eating style may be a result of high levels of weight and high levels of weight concern in the habitual high consumers of artificial sweeteners. A high B.M.I. or weight concern in the habitual high consumers however, can not explain the differing responses to sweetness and energy. Differing responses to sweetness and energy can only be explained as a direct result of the habitual uncoupling of sweetness and energy, as a demonstration of an extinction of the natural sweetness-energy relationship. Effects in male participants and differences between males and females can be explained as a result of a lesser importance of taste in appetite in males or as a result of a lesser concern over weight.

Uncoupling sweetness and energy in habitual high consumers of artificial sweeteners thus, is associated with various effects on appetite and appetite control. The majority of these effects are considered to result from associations with the deliberate self-selection of a high consumption of artificial sweeteners - high levels of weight and weight concern. Evidence was also found however, suggesting an association with an extinction of the natural sweetness-energy relationship and an adaptation to sweetness.

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References: All previous papers cited in the text will be cited in full at all places in the text, due to the number of articles published by many of the authors cited and the wish to keep each article easily distinct from any others. For example, Blundell, Rogers and Hill, 1988 will be written as such throughout the text and will not be abbreviated to Blundell, et al, 1988.

Abstracts: Individual Study Abstracts are provided for all studies investigating the habitual consumption of sweetness without energy (Studies 3, 4, 5, 6, 7, and 8) at the start of each study. Due to the number and complexity of the results found for many of the studies, abstracts are intended to highlight all important results prior to the actual results sections, to allow easier reading and understanding.

List of Terms Used

Appetite: Throughout this thesis, the term 'appetite' refers to a propensity toward consumption, and includes all subjective experiences of hunger - hunger, thirst, desires to eat, cravings; and all behavioural manifestations of those subjective experiences - food intake, fluid intake. 'Specific appetites' or 'appetites for ...' refer to a propensity toward consumption for a specific food item - food preferences / choices.

Appetite Control: Throughout this thesis, the term 'appetite control' refers to the control of appetite - i.e. the control of consumption. All factors influential in the control of consumption are referred to as appetite controls. These factors include internal sensations - e.g. hunger, fullness, perceptions of palatability, cognitions, emotions; and external and situational factors.

Artificial Sweetener: Throughout this thesis, the term 'artificial sweetener' will refer only to artificially-created sweetening agents, which contain only minimal energy value, e.g. aspartame, saccharin, (otherwise termed intense sweeteners, high intensity sweeteners or non-nutritive sweeteners). Bulk sweeteners, e.g. sorbitol, xylitol, are not included in this term and will not be considered in this thesis.

Satiety: Throughout this thesis, the term 'satiety' will refer to the experience of a partial or complete satisfaction of hunger following ingestion, regardless of the continuation or discontinuation of ingestion. No distinction will be made between satiety and satiation.

List of Abbreviations

A.D.A. - American Dietetic Association
ANOVA - Analysis of Variance
ANCOVA - Analysis of Variance with Covariates
A.U.C. - Area under the Curve (Hulshof, de Graaf and Westrate, 1993)
B.M.I. - Body Mass Index
B.M.R. - Basal Metabolic Rate
Consumers -
- HC - High Consumers of Artificially-Sweetened Beverages
- LC - Low Consumers of Artificially-Sweetened Beverages
- WC - Low Consumers of Artificially-Sweetened Beverages, High Consumers of Non-Sweetened Low Energy Beverages
- AC - High Consumers of Artificially-Sweetened Beverages
- NC - Low Consumers of Artificially-Sweetened Beverages, High Consumers of Naturally Sweetened Beverages

D.E.B.Q. - Dutch Eating Behaviours Questionnaire (van Strien, Frijters, Bergers and Defares, 1986)
E.D.I. - Eating Disorder Inventory (Garner, Olmstead and Polivy, 1983)
F.F.Q. - Food Frequency Questionnaire
MAFF - Ministry of Agriculture, Food and Fisheries, U.K.
MANOVA - Multivariate Analysis of Variance
Preloads -
- W - Water, Non-Sweet / Low Energy Drink Preload
- AS - Artificially Sweetened, Sweet / Low Energy Drink Preload
- NS - Naturally Sweetened, Sweet / High Energy Drink Preload
- S - Sweet Lunch Preload
- NS - Non-Sweet Lunch Preload

SPSS. - Statistical Package for Social Scientists
T.F.E.Q. - Three Factor Eating Questionnaire (Stunkard and Messick, 1985)
U.K. - United Kingdom
U.S.A. - United States of America
V.A.S. - Visual Analogue Scales
Y.E.P.Q. - Yale Eating Patterns Questionnaire (Kristeller and Rodin, 1989)

approx. - approximately
cm. - centimetres
freq. - frequency
g. - grammes
gram. - grammes
hr. - hours
kcal. - kilocalories
kg. - kilogrammes
lb. - pounds
m. - metres
min. - minutes
mg. - milligrammes
ml. - millilitres
mm. - millimetres
mph. - miles per hour
n.s. - non-significant
st.dev. - standard deviation
vs. - versus

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Publications and Presentations arising from this Thesis

Publications

King, N.A., Appleton, K.M., Rogers, P.J., & Blundell, J.E. (in press). The Effects of Drinks containing Artificial Sweeteners or Sucrose on Food Intake following Exercise'. Physiology and Behaviour,

Appleton, K.M., Conner, M.T. & Blundell, J.E. (1998). Uncoupling Sweetness and Energy in Habitual Consumers of 'Diet' Drinks: Effects on Short Term Appetite. Appetite, 29, 231-232 (abstract)

Appleton, K., & Conner, M. (1998). Habitual High Consumers of 'Diet Drinks': Effects on Short Term Appetite of a Sweet vs. a Savoury Lunch. International Journal of Obesity, 22, supplement 3, s142 (abstract)

Appleton, K.M., King, N.A., Rogers, P.J., & Blundell, J.E. (1996). The Effects of Drinks containing Artificial Sweeteners or Sucrose on Food Intake following Exercise. International Journal of Obesity, 20, supplement 4, s67 (abstract)

Presentations

Appleton, K.M., King, N.A., Rogers, P.J., & Blundell, J.E. The Effects of Drinks containing Artificial Sweeteners or Sucrose on Food Intake following Exercise. - poster presentation at the Seventh European Congress on Obesity, Barcelona, Spain, (international conference), May, 1996.

Appleton, K.M., Conner, M.T. & Blundell, J.E. Uncoupling Sweetness and Energy by the Habitual Consumption of 'Diet' Drinks: Effects on Appetite. - oral presentation at the British Feeding and Drinking Group, Dundee, U.K., (national conference), April, 1997.

Appleton, K.M., Conner, M.T. & Blundell, J.E. Uncoupling Sweetness and Energy in Habitual Consumers of 'Diet' Drinks: Effects on Short Term Appetite. - oral presentation at the Sixth Food Choice Conference, Uppsala, Sweden, (international conference), June, 1997.

Appleton, K.M., Conner, M.T. & Blundell, J.E. The Habitual High Consumption of 'Diet' Drinks: Effects on Short-Term Appetite of a Sweet vs. a Savoury Lunch - oral presentation at the British Feeding and Drinking Group, Bradford, U.K., (national conference), April, 1998.

Appleton, K., & Conner, M. Habitual High Consumers of 'Diet Drinks': Effects on Short Term Appetite of a Sweet vs. a Savoury Lunch. - poster presentation at the Eighth International Congress on Obesity, Paris, France, (international conference), September, 1998.

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Chapter 1.

SWEETNESS AND SWEETENERS

In the natural world, sweetness as a taste is almost always found in association with energy. Associated with energy and the subsequent physiological effects of energy, sweetness can exert a number of varied effects on appetite. With the development of artificial sweeteners (sweetness without energy) however, sweetness and energy can be effectively uncoupled. Uncoupling sweetness and energy, the consumption of artificial sweeteners may have profound effects on appetite and appetite control.

This thesis aims to discuss and investigate the effects on appetite and appetite control of uncoupling sweetness and energy, by the consumption of artificial sweeteners, or more accurately by the consumption of sweetness without energy. The effects of a single consumption of sweetness without energy have previously been widely investigated. These effects will be discussed in Chapter 2, and investigated in Study 1. The effects of the habitual consumption of sweetness without energy on appetite however, remain uninvestigated. The habitual consumption of sweetness without energy, as achieved by the habitual consumption of artificial sweeteners may have profound effects on appetite. Possible effects will be discussed in Chapter 3, and investigated in Studies 2-8. This chapter firstly discusses sweetness, artificial sweeteners, and their effects on appetite.

1.1. SWEETNESS - *'a powerful psychobiological phenomenon'* *(Blundell, Rogers and Hill, 1988b, p.148)*

Sweetness is, by nature, a psychobiological phenomenon - a combination of the psychological, the biological and an interaction of the two. Psychologically, sweetness is a powerful taste sensation. Ingestion of any sweet stimuli will result in the immediate stimulation of specific receptors on the tongue (Birch, 1997a; Birch, 1997b), and the immediate experience of sweetness as a taste via neural connections to the brain (Scott and Giza, 1987). Biologically, sweetness in nature, is a taste afforded predominantly by only a distinct number of biologically active simple carbohydrates. On ingestion, these simple carbohydrates are digested and absorbed into the blood stream, and like many carbohydrates become available to the ingesting organism as a source of fuel (MAFF, 1995). Psychobiologically, the psychological taste sensation and the biological simple carbohydrates are not independent. Taste and biological activity are connected. Via the brain, the central nervous system (most notably the Vagus Nerve), and to a lesser degree the endocrine system (Carlson, 1986), the experience of sweet taste can have a powerful effect on the biological fate of the simple carbohydrates, and the biological activity of simple carbohydrates can have a marked effect on the psychological experience of sweet taste (Scott and Giza, 1987).

Psychological, biological and psychobiological, sweetness can exert a number of varied and potent effects on appetite (Blundell, Rogers and Hill, 1988b).

1.1.1. EFFECTS ON APPETITE: PSYCHOLOGICAL

Psychologically, sweetness can exert effects on appetite as a taste. Sweetness is a highly pleasing and highly preferred taste sensation. Neonates seem to show an innate preference for sweetness (Beauchamp and Cowart, 1987) and, though possibly more influential in food choice in young children (Birch and Marlin, 1982), this preference seems not to dissipate throughout life (see Beauchamp and Cowart, 1987). For the majority of individuals sweetness remains highly pleasurable and inherently rewarding. Sweetness furthermore seems fairly resistant to sensory-specific-satiety - i.e. the perceived pleasantness of sweetness is little diminished by recent experience of the sensation (Rolls, Rolls, Rowe and Sweeney, 1981). The consequent effects of sweetness on appetite are simple: highly preferred and psychologically rewarding, sweetness will be much sought after and, if available, much consumed.

1.1.2. EFFECTS ON APPETITE: BIOLOGICAL

Biologically, sweetness can affect appetite by virtue of its simple carbohydrate composition (Blundell and Rogers, 1994). Complex (starch) and simple carbohydrates (sugars) are a major source of energy for humans. Starch is digested and stored to provide an available source of energy. Sugars (monosaccharides - glucose, fructose and galactose; and dissaccharides - sucrose, maltose and lactose), by comparison, are easily digested and may be stored or can be used directly for energy (MAFF, 1995). Direct energy can be expected to have an immediate effect on appetite in the direction of appetite reduction.

1.1.3. EFFECTS ON APPETITE: PSYCHOBIOLOGICAL

Psychobiologically, sweetness can also exert effects on appetite by virtue of the reliable association between the psychological experience of sweet taste and the biological activity of the simple carbohydrates. On a simple level, sweet taste and the biological activity of simple carbohydrates are associated reflexively, by Cephalic Phase Reflexes. On a more complex level, sweet taste and the biological activity of simple carbohydrates are also associated through Associative Conditioning. The increased complexity of associative conditioning lies in the necessary consideration of instrumental as well as classical conditioning processes (Mackintosh, 1974). Both, cephalic phase reflexes and associative conditioning however, depend on the reliability of the association between sweet taste and the biological activity of the simple carbohydrates.

1.1.3.1. Cephalic Phase Reflexes

Cephalic Phase Reflexes are responses, triggered by the sight, smell, taste and expectation of food, which act to prepare the digestive system for the arrival of food (Teff, 1994; Carlson, 1986). Of particular relevance to sweetness is the Cephalic Phase Insulin Response, a cephalic phase reflex secretion of insulin from the pancreas (Carlson, 1986). On ingestion, simple sugars are absorbed directly into the blood stream and rapidly cause blood hyperglycaemia. This hyperglycaemia is subsequently reduced by the secretion of insulin. By the repeated association of the taste of sweetness with simple sugars, the taste of sweetness also becomes associated with blood hyperglycaemia. Once the association has been learnt, the taste of sweetness itself results in the secretion of insulin. The secretion of insulin prior to requirements facilitates digestion by facilitating glucose storage prior to the absorption of the food, but also results in hypoglycaemia. This hypoglycaemia, however is immediately rectified by the ingested sugars (Carlson, 1986).

The cephalic phase insulin response has been repeatedly demonstrated (e.g. Teff, Devine and Engelman, 1995; Teff, 1994; Teff, Mattes and Engelman, 1991; Bruce, Storlein, Furler and Chisholm, 1987; Simon, Schlienger, Sapin and Imler, 1986; Yamazaki and Sakaguchi, 1986). Effects however are far from reliable (Abdullah, Chabert and Louis-Sylvestre, 1997; Teff, Devine and Engelman, 1995; Teff, 1994; Carlson and Shah, 1989; Bruce, Storlein, Furler and Chisholm, 1987), but are considered to depend very much on the methodology of the investigatory studies - the participants used, the methods of blood sampling used, and perhaps most importantly, the stimuli used (Abdullah, Chabert and Louis-Sylvestre, 1997; Teff, Devine and Engelman, 1995; Bruce Storlein, Furler and Chisholm, 1987). The cephalic phase insulin response is a response to the ingestion of sugars - studies lacking in either a sweet taste or an ingestion action, e.g. chewing, may simply be using stimuli not strong enough to elicit a response (Teff, 1994). The necessary presence and importance of the cephalic phase insulin response is easily seen in studies where the response is inhibited or absent. Inhibition of the response results immediately in hyperglycaemia and subsequent hyperinsulinaemia, and has been implicated in abnormal glucose metabolism and the development of diabetes mellitus (see Teff, 1994).

The value of the cephalic phase insulin response in appetite regulation is clear. On learning the association between the taste of sweetness and the biological activity of simple sugars, sweetness can cue the subsequent biological activity of the simple sugars and so facilitate digestion.

1.1.3.2. Associative Conditioning

Associative conditioning refers to the learning of an association by classical and instrumental processes (Mackintosh, 1974). The most obvious and frequently reported examples of associative conditioning in appetite are seen in food-aversion conditioning - a specific taste becomes associated with subsequent (not necessarily related) negative physiological effects, and is from then on avoided (Garcia, Hankins and Rusiniak, 1974). Recent research in animals, however, has demonstrated an ability to associate tastes with positive subsequent physiological effects (Sclafani, 1997; Capaldi, Owens and Palmer, 1994). These effects however, have only recently been tested in humans and demonstrated experimentally.

Birch, McPhee, Steinberg and Sullivan (1990) reported associative-conditioned preferences in young children, based on the subsequent physiological consequences of calories. After repeated association between a distinct taste and either a high or a low calorie drink, children showed increasing preference for the taste associated with the delivery of calories. No preferences were found for the taste associated with the low calorie drink. Similarly, associative conditioning has been demonstrated by Booth, Mather and Fuller (1982) and Booth and Toase (1983). In both studies, specific tastes were presented repeatedly with either a higher calorie (starch augmented) or a lower calorie (not starch augmented) food. After association, preferences were found for the taste associated with the subsequent physiological consequences of the increased calories. In these studies however the value of the conditioning was also demonstrated: effects were only present when participants were in states of energy depletion. Similar associative conditioning effects have also been reported to the physiological consequences of protein. Gibson, Wainwright and Booth (1995), using a conditioning paradigm and testing procedure as above, found that:

> *'human preference for and intake of a food at lunch was increased when the flavor of that food was paired with an adequate supply of protein, following a breakfast lacking in protein' (p.363).*

Tastes reliably associated with specific physiological consequences can have strong and important effects on appetite.

In nature, the taste of sweetness is reliably associated with simple carbohydrate energy, or more specifically, with the physiological effects of that energy - satiety. By the association of the taste of sweetness with these simple sugars, sweetness will also become associated with satiety. On learning the association, the taste of sweetness itself will result in perceptions of satiety. The taste of sweetness thus may provide a very efficient means of appetite control.

The learning of the association between sweetness and energy by associative conditioning will also be enhanced by the positive aspect of satiety (Capaldi, Owens and Palmer, 1994; Tordoff, 1988b, Scott and Giza, 1987). Whilst the consumption of sweetness is reinforced by the subsequent positive feelings of satiety, sweetness will continue to be consumed and the association between sweetness and energy will be continually strengthened. The positive aspect of satiety and its association with sweetness has long been postulated as the origin of sweetness preferences (Rozin 1987; Scott and Giza, 1987).

1.1.4. SUMMARY

Naturally, thus, sweetness can have a variety of powerful effects on appetite - increasing consumption, appetite reduction, digestion facilitation and efficient appetite control. The psychological effects (i.e. the subjective experience of sweet taste) furthermore, increasing consumption, will strengthen all others. With the exception of these psychological effects however, all effects on appetite depend on the existence of sweetness as an energy-yielding simple carbohydrate - i.e. depend on the presence of energy, and the reliable association between sweetness and the physiological effects of energy. The strength of the association between sweetness and energy furthermore, should not be underestimated. At birth, sweetness is consistently provided in association with energy as lactose in mothers milk (MAFF, 1995). From then on sweetness will continue to be associated with energy in all natural sugars, as found in fruit, milk, and honey (MAFF, 1995).

1.2. ARTIFICIAL SWEETENERS - a psychological nonbiological phenomenon

With the development of artificial sweeteners however, the association between sweetness and energy is no longer guaranteed. Artificial sweeteners, also termed high intensity sweeteners and non-nutritive sweeteners, exist as sweetening agents, devoid of calories. Between 30 - 3000 times sweeter than sucrose (Newsome, 1993), six different artificial sweeteners are permitted in food in the U.K. - acesulfame-K, aspartame, cyclamates, neohesperidine DC, saccharin, and thaumatin (Sweeteners in Food Regulations, 1995). Details of these sweeteners are given in Table 1.1. Of these, those used most frequently and most widespread are aspartame, saccharin and acesulfame-K, and use and consumption is rapidly increasing. Between 1986 and 1991, the percentage of the U.S. population regularly consuming artificial sweeteners increased from 45% to 54% (Nabors and Lemieux, 1993). This trend is continuing (Alexander and Tepper, 1995; Nabors and Lemieux, 1993), and is similar in most western countries, including the U.K. (MAFF, 1990). For the food manufacturer, artificial sweeteners are economical substitutes for natural sugars (Newsome, 1993). For the general consuming public, artificial sweeteners are welcome aids in weight maintenance or weight loss (Alexander and Tepper, 1995). Artificial sweeteners contribute substantially to the taste of foods, yet provide only minimal energy value.

Table 1.1: Details of All Artificial Sweeteners Permitted in the U.K.

Artificial Sweetener - Common Name (Full Name) [Chemical Structure where available]	Sweetness *
Acesulfame-K (Acesulfame Potassium) [6-methyl-1,2,3-oxathiazine-4(3H)-one-2,2-dioxide]	200
Aspartame [L-α-aspartyl-L-phenylalanine-1-methyl Ester]	200
Cyclamates [Acid, Na salts, Ca salts]	30
Neohesperidine DC (Neohesperidine Dihydrochalcone)	1250
Saccharin [Ortho-sulfamoylbenzoic Acid, Na Salts and Ca Salts]	300
Thaumatin	3000

* Approximate Relative Sweetness, where the Sweetness Index of Sucrose = 1
(Details taken from Birch (1997a) and Newsome (1993).)

1.2.1. EFFECTS ON APPETITE

Contributing substantially to the sweet taste of foods, yet providing minimal energy value, artificial sweeteners may be expected to have only very limited effects on appetite. All effects would be expected to be effects of taste - those described earlier as psychological (section 1.1.1). Artificial sweeteners, however, may exert a much more powerful effect on appetite. Existing as sweet taste but without the subsequent physiological effects of energy, sweeteners can seriously challenge the reliable association between sweetness and energy. With reference to the previous discussion on the effects on appetite as a result of the association between sweetness and energy, this uncoupling of sweet taste and energy may have profound effects on appetite. The effects on appetite of the uncoupling of sweetness and energy is the main focus of this thesis.

1.3. SUMMARY

In summary, sweetness, as found in natural sugars, can exert effects on appetite as a psychological taste, as an energy-providing simple carbohydrate, and as a result of the reliable association between the taste and the energy. Sweeteners, in comparison, as taste without energy, can exert effects on appetite only as a psychological taste. As taste without energy however, artificial sweeteners can effectively uncouple sweetness and energy. The uncoupling of sweetness and energy may have profound effects on appetite and appetite control.

Chapter 2.

UNCOUPLING SWEETNESS AND ENERGY

As discussed in the previous chapter, sweetness can have a major effect on appetite by virtue of the reliable association between sweetness and the subsequent physiological effects of energy. With the development of artificial sweeteners however, sweetness and energy can be uncoupled. Uncoupling sweetness and energy, the consumption of artificial sweeteners, or the consumption of sweetness without energy, may have a number of effects on appetite. The effects on appetite of artificial sweeteners as sweetness without energy have been widely investigated (see Renwick, 1994; Rolls, 1991). Previous research can broadly be classified as: research into the single consumption of sweetness without energy; research into the repeated consumption of sweetness without energy; and research into the habitual consumption of sweetness without energy.

2.1. METHODOLOGICAL DETAILS

Effects on appetite can be demonstrated using a preload procedure. Artificial sweeteners / sweetness without energy is given as a preload and subsequent appetite is measured using subjective measures, e.g. ratings of hunger; physiological / biochemical measures, e.g. levels of blood glucose; and/or behavioural measures e.g. test meal intake (see Hill, Rogers and Blundell, 1995). The effects on appetite of preloads, however, can only be fully understood if appropriate preloads are compared (Rogers and Blundell, 1989a). Investigation of the effects on appetite of sweetness without energy requires either:

- a comparison of equi-energetic preloads differing in sweetness (additive principle), or:
- a combination of the above comparison and a comparison of equi-sweet preloads differing in energy content (substitutive principle) (Rogers and Blundell, 1989a).

The inclusion of the substitutive procedure depends on the caloric content of all preloads; only zero calorie preloads can investigate the effects on appetite of sweetness without energy using only the additive procedure. In all comparisons,

> *'all other factors, including acceptability, must be held constant' (Rogers and Blundell, 1989a, p.274)*

2.2. SINGLE CONSUMPTION

The majority of research has investigated the effects on appetite of a single consumption of sweetness without energy.

2.2.1. PREVIOUS RESEARCH

A review of recent previous research investigating a single consumption of sweetness without energy in humans is found in Table 2.1. In view of the methodological considerations above however, only studies involving appropriate additive and/or substitutive comparisons have been included in the table. Studies omitting the additive procedure have been excluded (Anderson, Saravis, Schacher, Zlotkin and Leiter, 1989; Rolls, Laster and Summerfelt, 1989). Studies omitting the substitutive procedure when investigating caloric preloads have been excluded. Studies involving additional factors in either additive or substitutive comparisons have also been excluded - comparison of a preload and no preload (Tordoff and Alleva, 1990b; Wardle, 1987b), comparison of water and fizzy flavoured drinks (Rolls, Kim and Fedoroff, 1990), comparison of liquid and solid foods (Teff, Devine and Engelman, 1995), comparison of foods differing in macronutrient content (Macht, 1996; Rolls, Hetherington, Burley and van Duijvenvoorde, 1986). Studies involving comparison of non-sweet non-flavoured preloads and sweet flavoured preloads have been included. Additional flavour can be considered necessary for equivalent levels of palatability/acceptability between preloads. Also, for simplicity, only significant results have been reported in the table, marginally significant results and trends have not. Table 2.1 can be found at the end of the chapter.

2.2.2. PREVIOUS RESEARCH REVIEWED

In summary of Table 2.1, in five of the twenty two studies, sweetness without energy resulted in increases in appetite when measured subjectively (Black, Leiter and Anderson, 1993; Tordoff and Alleva, 1990b; Rogers and Blundell, 1989b; Rogers, Carlyle, Hill and Blundell, 1988; Blundell and Hill, 1986). In five studies, sweetness without energy resulted in increases in appetite when measured behaviourally (Reid and Hammersley, 1995; Guss, Kissileff and Pi-Sunyer, 1994; Rogers, Pleming and Blundell, 1990; Rogers and Blundell, 1989b; Brala and Hagen, 1983). In one study, the perceived pleasantness of foods also increased (Rogers, Carlyle, Hill and Blundell, 1988). Absence of effects were reported in subjective measures in nine studies (Black, Tham and Citron, 1994; Guss, Kissileff and Pi-Sunyer, 1994; Black, Leiter and Anderson, 1993; Black, Tanaka, Leiter and Anderson, 1991; Canty and Chan, 1991; Rogers, Pleming and Blundell, 1990; Rogers and Blundell, 1989b; Rogers, Carlyle, Hill and Blundell, 1988; Brala and Hagen, 1983), in behavioural measures in twelve studies (Reid and Hammersley, 1995; Black, Tham and Citron, 1994; Guss, Kissileff and Pi-Sunyer, 1994; Black, Leiter and Anderson, 1993; Black, Tanaka, Leiter and Anderson, 1991; Canty and Chan, 1991; Rodin, 1990; Rogers, Pleming and

Blundell, 1990; Birch, McPhee and Sullivan, 1989; Rogers and Blundell, 1989b; Rogers, Carlyle, Hill and Blundell, 1988; Brala and Hagen, 1983), and in the perceived pleasantness of foods in two studies (Black, Leiter and Anderson, 1993; Black, Tanaka, Leiter and Anderson, 1991). Only four studies found a decrease in appetite following sweetness without energy: Birch, McPhee and Sullivan (1989), investigating subsequent intake, in two studies conducted on children; Black, Leiter and Anderson (1993), where a reduction in the perceived pleasantness of foods was found, although hunger was simultaneously increased; Guss, Kissileff and Pi-Sunyer, 1994, where a reduction in intake was reported following 1% glucose and aspartame solution. The effects in children will be referred to later in the discussion of this thesis (Chapter 13, section 13.2.2.1). The reduction in the perceived pleasantness of foods found by Black, Leiter and Anderson (1993) may be a demonstration of a reduction of perceived pleasantness of sweetness - an unexpected phenomenon reported in studies involving artificial sweeteners, as reported in Table 2.1 by Blundell and Hill (1986). The reduction in intake following a 1% glucose and aspartame solution remains unexplained (Guss, Kissileff and Pi-Sunyer, 1994). Evidence from biological measures of appetite is equivocal. Increases in insulin levels and decreases in glucose levels were demonstrated in two of the studies in Table 2.1 (Bruce, Storlien, Furler and Chisholm, 1987; Kun and Horvath, 1948). Absence of effects were reported in five of the studies (Abdullah, Chabert and Louis-Sylvestre, 1997; Teff, Devine and Engelman, 1995; Rodin, 1990; Carlson and Shah, 1989; Bruce, Storlien, Furler and Chisholm, 1987).

In conclusion, the consumption of sweetness without energy can stimulate appetite, although effects may be quite subtle, hard to detect and/or easily overridden by other factors. Effects are more frequently found in subjective than behavioural measures. Evidence of biochemical mediation is equivocal.

2.2.3. PREVIOUS RESEARCH UNDERSTOOD

The stimulation of appetite by sweetness without energy can be understood with reference to the reliable association between sweetness and energy. As discussed in the previous chapter, sweetness can have a major effect on appetite through the association between sweetness and energy. By association, sweetness as a taste can cue the subsequent physiological effects of energy. Consequently, a sweet taste will result in the anticipation of subsequent energy and these physiological effects. By the consumption of sweetness without energy however, this anticipation will be unfulfilled. Reflexively, the taste of sweetness will result in the secretion of insulin, resulting in blood hyperinsulinaemia and hypoglycaemia. By the consumption of sweetness without energy, this hyperinsulinaemia and hypoglycaemia will not be counteracted by the arrival of glucose/energy.

Hypoglycaemia would be expected to result in increases in appetite. By associative conditioning, the taste of sweetness will result in feelings of satiety. By the consumption of sweetness without energy however, these feelings of satiety will not be supported by actual experiences of satiety. The discrepancy between feelings of satiety and actual satiety would be expected to result in increases in appetite (see Blundell, Rogers and Hill, 1988b).

2.2.4. FINER METHODOLOGICAL DETAILS

The conclusions drawn above however, are far from definitive. Effects on appetite may be greatly influenced by some of the finer methodological details of the above studies:

2.2.4.1. The Artificial Sweeteners

The three artificial sweeteners most commonly used in consumption and in investigations are saccharin, aspartame and acesulfame-K. All are chemical compounds (A.D.A. Report, 1993) and may differentially affect appetite (e.g. Rogers, Carlyle, Hill and Blundell, 1988 (see Table 2.1)). Firstly, all artificial sweeteners differ in actual taste; saccharin, for example, has a slightly bitter/metallic aftertaste (A.D.A. Report, 1993). Secondly, all artificial sweeteners have differing chemical properties; the structure and taste of aspartame, for example, is easily destroyed by heat (Newsome, 1993). Thirdly, all artificial sweeteners are composed of differing chemical components which on digestion may affect appetite. Of the three artificial sweeteners most commonly used however, the possibility of effects following digestion only apply to aspartame. Saccharin and Acesulfame-K (Acesulfame-Potassium) are not metabolized by humans (or their intestinal bacteria), but remain pharmacologically inactive and are rapidly excreted (Tordoff, 1988a; von Rymon Lipinski, 1988). The chemical structures of saccharin and acesulfame-K thus, are unlikely to affect appetite. Aspartame, however, can be metabolized.

Aspartame (L-α-aspartyl-L-phenylalanine-1-methyl ester) is a dipeptide, and on ingestion is hydrolysed to produce aspartate, phenylalanine and methanol (Stegink, 1984). Of these, phenylalanine may exert direct effects on appetite: as a releaser of CCK, a physiological mediator of satiety; or via tyrosine as a precursor of the neurotransmitters Dopamine and Noradrenaline (Rogers, Keedwell and Blundell, 1991). Aspartate and phenylalanine may also exert indirect effects on appetite by creating an imbalance in large neutral amino acid (LNAA) levels in the blood, so potentially affecting mood and possibly subsequent intake (Ryan-Harshman, Leiter and Anderson, 1987; Coulombe and Sharma, 1983).

The ingestion of aspartame has been associated with subsequent dose dependant increases in blood levels of phenylalanine, tyrosine and methanol, and increases in blood ratios of phenylalanine and tyrosine to other LNAA (Spiers, Sabounjian, Reiner, Myers, Wurtman and Schomer, 1998; Rogers and Blundell, 1994; Ryan-Harshman, Leiter and Anderson, 1987; Stegink, Filer and Baker, 1981; Stegink, Filer and Baker, 1979; Stegink. Filer and Baker, 1977). The effects of these compounds on appetite however are less well substantiated. Encapsulated aspartame has been associated with a reduction in appetite (Rogers, Burley, Alizhanizadeh and Blundell, 1995; Rogers, Keedwell and Blundell, 1991; Rogers, Pleming and Blundell, 1990), as has encapsulated phenylalanine (Rogers and Blundell, 1994). Other studies however have found no effects on appetite (Rogers and Blundell, 1994; Anderson, Saravis, Schacher, Zlotkin and Leiter, 1989; Ryan-Harshman, Leiter and Anderson, 1987), or have found effects on appetite following aspartame, but in the absence of effects following phenylalanine (Rogers, Keedwell and Blundell, 1991). Whilst more research is obviously still required, aspartame ingestion may result in appetite reduction, via phenylalanine. This potential effect must be borne in mind when interpreting all sweetness/energy investigations involving aspartame.

The quantities of artificial sweetener used will also have differing effects on appetite (e.g. Tordoff and Alleva, 1990b). Valid investigations require the use of sweetness intensities that are easily discernible, yet not unpalatable (see Brala and Hagen, 1983).

2.2.4.2. The Comparison Sugars

In comparing equi-sweet preloads of differing energy contents, differential effects on appetite may also be achieved by differing comparative natural sugars (e.g. Guss, Kissileff and Pi-Sunyer, 1994; Rodin, 1990 (see Table 2.1)). All natural sugars and manufactured sugar syrups differ slightly in taste and in intensity - the sweetest being fructose (MAFF, 1995). All are also digested and metabolized slightly differently - monosaccharides (glucose, fructose and galactose) are easily absorbed and immediately available as an energy source, dissaccharides (sucrose, maltose and lactose) must first be split into monosaccharides, and sugar syrups (e.g. glucose syrup, high fructose corn syrup) must be broken down and then digested (MAFF, 1995). Differences in effects on appetite seem obvious (and see Anderson, 1995). The quantity of comparison sugars used will also affect appetite, due to taste, intensity, palatability (see Brala and Hagen, 1983) and more importantly due to the energy provided - smaller quantities of comparison sugars will result in smaller comparative energy contents, resulting in smaller and less detectable effects (Blundell and Green, 1996).

2.2.4.3. The Vehicles

Differing vehicles may differentially affect appetite. Differing vehicles will firstly taste different and may also differentially affect the taste of additional sweeteners (Tordoff, 1988a). Secondly, differing vehicles may differentially affect many ingestion/digestion processes - e.g. rate of gastric emptying, rate of absorption, and may activate different osmotic controls of food intake (Tordoff, 1988a). Thirdly, caloric vehicles may also differentially affect appetite by the ingestion of differing nutrients (Tordoff, 1988a).

2.2.4.4. The Measures of Appetite

Appetite can be measured subjectively, physiologically and behaviourally. All measure appetite, but from different, related but not dependant, perspectives (Wardle, 1987b). Subjective measures may be unassociated with physiological measures and, either or neither may be acted on behaviourally. Behavioural measures of appetite may be completely unassociated with subjective or physiological measures (Wardle, 1987b). Differences in measured appetite can also occur within measurement types - most notably, test meal intake measures may differ markedly between test meal types dependent on palatability, familiarity, variety and number of foods (Blundell and Green, 1996). Differences in measurement outcome can also be achieved as a function of the methodological procedure of the study (Blundell and de Graaf, 1993); of most potential influence - the length of the time interval between preload and measurement (e.g. Birch, McPhee and Sullivan, 1989), and all events occuring within that time interval. The ingestion of foods between preload and measurement can drastically alter measurement outcomes (Blundell and Green, 1996). (Studies involving contamination of measurements were also excluded from Table 2.1.)

2.2.4.5. The Participants

Effects on appetite will also differ in differing participants. Differences in appetite measures have previously been found between males and females (Rolls, Fedoroff and Guthrie, 1991), between adults and children (see Birch, McPhee, Steinberg and Sullivan, 1990), between lean, overweight and obese individuals (e.g. Prentice, Black, Murgatroyd, Goldberg and Coward, 1989; Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1985; Witherly, Pangborn and Stern, 1980), between restrained and unrestrained individuals (e.g. Fedoroff, Polivy and Herman, 1997), etc. Differences in effects on appetite will also occur depending on the state of the participant - whether they are hungry or satiated, informed or uninformed of their situation, familiar or unfamiliar with their situation (Rolls, 1991), etc. The significance of observed effects on appetite will also be greatly affected by the number of participants studied (Blundell and Green, 1996) and the study design (within-subjects and between-subjects) (Coolican, 1990).

2.2.5. SUMMARY

In summary, following extensive investigation, a single consumption of sweetness without energy can be found to stimulate appetite. This increase in appetite is easily understood with reference to the reliable association between sweetness and energy, as discussed in Chapter 1, although the biochemical mediation of effects is yet to be fully determined. Effects however are subtle and may be difficult to detect and/or easily overridden. Difficulty in detection is further increased by the use of inappropriate experimental designs and confounded experimental procedures.

2.3. REPEATED CONSUMPTION

A single consumption of sweetness without energy however (unless through deliberate choice) is increasingly unlikely. With the increased availability and use of artificial sweeteners, the uncoupling of sweetness and energy can, and will, be experienced repeatedly. Previous research has also addressed the effects on appetite of the repeated consumption of sweetness without energy.

2.3.1. PREVIOUS RESEARCH

The effects on appetite of the repeated consumption of sweetness without energy have been poorly researched. The majority of studies conducted in this area have simply investigated the effects on appetite of artificial sweeteners when substituted for sugar or other caloric sweeteners (Naismith and Rhodes, 1995; Steiniger, Graubaum, Steglich, Berlin and Metzler, 1995; Evans, 1989; Louis-Sylvestre, Tournier, Verger, Chabert, Delorme and Hossenlopp, 1989; Foltin, Fischman, Emurian and Rachlinski, 1988; van Itallie, Yang and Porikos, 1988; Porikos, Hesser and van Itallie, 1982). With reference to the discussion on experimental design (section 2.1), the effects on appetite of sweetness uncoupled from energy can only be fully investigated using either the additive comparison, or a combination of the additive and substitutive comparisons. Use of substitutive comparisons only will result in the investigation of energy reduction only. (The effects on appetite of energy reduction and artificial sweeteners, as demonstrated in these studies, will be referred to in Chapter 3.)

A minority of studies however are applicable to the sweetness/energy question, all containing both additive and substitutive comparisons. Details of these studies are given in Table 2.2. Only appropriate comparisons have been included in the table - comparisons of preload and no preload have been excluded (Tordoff and Alleva, 1990a), comparisons of preloads differing in macronutrient content have been excluded (Mattes, 1990). Appropriate comparisons within these studies have been included in the table, due to the lack of research in this area, but outcomes of these appropriate comparisons should be treated with caution. Table 2.2 is displayed at the end of the chapter.

2.3.2. PREVIOUS RESEARCH REVIEWED

In summary of Table 2.2, the repeated consumption of sweetness without energy has only been fully investigated in two studies - Lavin, French and Read (1997) and Addington (PhD thesis, 1988). In the shorter 2-day study by Lavin, French and Read (1997), sweetness without energy was found not to affect subjective or behavioural appetite on Day 1, but resulted in an increase in appetite when measured behaviourally on Day 2. The absence of effects on Day 1 may simply be due to insensitive laboratory procedures (Lavin, French and Read, 1997). The absence of effects of sweetness in both subjective and behavioural measures was also reported by Mattes (1990), but similarly may have been due to testing environment (Mattes, 1990). In the longer 20-30 day study, Addington (PhD thesis, 1988) found sweetness without energy to lead to increases in appetite when measured subjectively, and when measured behaviourally as consumption of sweet foods. Total intake was not measured however, and no changes were found in body weight. The effects of energy reported by Tordoff and Alleva (1990a) may be attributed to the methodology of the study (Tordoff and Alleva, 1990a). Biochemical effects on appetite of the repeated consumption of sweetness without energy have not been investigated.

In conclusion, the repeated consumption of sweetness without energy can stimulate appetite, but effects are small, in relation to normal appetite variation, and may be difficult to detect and/or easily overridden.

2.3.3. PREVIOUS RESEARCH UNDERSTOOD

These effects on appetite are very similar to those found in response to a single consumption of sweetness without energy. As the repetition of single consumption, the effects on appetite of repeated consumption can be understood as a repetition of the effects on appetite of single consumption. The effects on appetite of single consumption are explained, with reference to the reliable association between sweetness and energy, as a result of a hypoglycaemia not counteracted by the arrival of glucose/energy, and a discrepancy between feelings of satiety and actual satiety. The repeated consumption of sweetness without energy appears to result in the repeated experience of a hypoglycaemia not counteracted by the arrival of energy, and the repeated experience of the discrepancy between feelings of satiety and actual satiety. Both these experiences would be expected to result in the repeated experience of increases in appetite. The repeated consumption of sweetness without energy thus results in repeated increases in appetite.

Few other plausible explanations can be given for the increase in appetite found in response to the repeated consumption of sweetness without energy. The explanation above however, does assume that sweetness remains associated with the physiological effects of energy, that sweetness and energy remain reliably associated. Other possible explanations for an increase in appetite following the repeated consumption of sweetness without energy can be given if sweetness and energy are no longer assumed to be reliably associated. For the purposes of this thesis however, the possibility of a disruption to the natural relationship will only be considered a possible result of the habitual consumption of sweetness without energy.

All effects on appetite of the repeated consumption of sweetness without energy, may also be influenced by methodological factors (see section 2.2.4).

2.3.4. SUMMARY

In summary, the effects on appetite of the repeated consumption of sweetness without energy - the repeated stimulation of appetite, are most plausibly explained as a repetition of the effects on appetite of the single consumption of sweetness without energy. These effects are explained with reference to the reliable association between sweetness and the subsequent physiological effects of energy.

2.4. HABITUAL CONSUMPTION

The habitual consumption of sweetness without energy is an extension of repeated consumption. Studies investigating repeated consumption, are typically short term - consumption and measurement lasting from 2 days to approximately 30 days. The availability and use of artificial sweeteners, however, may be much more long term. Repeated consumption may be extended into regular consumption over a time period of months or years. The habitual consumption of sweetness without energy, in this thesis, is defined as the regular consumption of sweetness without energy over an extended time period. The distinction between habitual consumption and repeated consumption lies in the extended quantity consumed and the extended period of consumption.

2.4.1. PREVIOUS RESEARCH

The effects on appetite of the habitual consumption of sweetness without energy remain unknown. To date, all research in this area simply investigates the effects on appetite of the habitual consumption of artificial sweeteners (Parker, Gonzalez, Derby, Gans, Lasater and Charleton, 1997; Morris, Cuneo, Stuart, Mance, Bell, Puleo, Ahmadi, Warde and Ripp. 1993; Smith and Heybach, 1988; Stellman and Garfinkel, 1986; Parham and Parham, 1980; McCann, Trulson and Stulb, 1956) and the long term value of artificial sweeteners as substitutes for sugar (Blackburn, Kanders, Lavin, Keller and Whatley, 1997; Gatenby, Aaron, Jack and Mela, 1997; Blackburn, Kanders, Lavin, Joy, Pontes and Folan, 1993; Kanders, Blackburn, Lavin, Whatley and Pontes, 1990; Kanders, Lavin, Kowalchuk and Blackburn, 1990; Kanders, Lavin, Kowalchuk, Greenberg and Blackburn, 1988). These studies provide valuable information on the effects on appetite of the habitual consumption of artificial sweeteners and the effects on appetite of the habitual consumption of sweetness with less energy. These studies however provide only very limited information on the effects on appetite of the habitual consumption of sweetness without energy. (The effects on appetite of artificial sweeteners and energy reduction will be referred to in Chapter 3.)

2.4.2. SUMMARY

In summary, the effects on appetite of the habitual consumption of sweetness without energy remain unknown.

2.5. SUMMARY

The effects on appetite of artificial sweeteners, as sweetness without energy have been extensively researched. Much of the work however, is only of limited value in investigating the effects on appetite of sweetness when uncoupled from energy, due to the use of inappropriate methodological designs or confounded procedures. Studies on the single and repeated consumption of sweetness without energy show sweetness uncoupled from energy can stimulate appetite; an effect that can be understood as a product of the reliable association between sweetness and the subsequent physiological effects of energy. The effects on appetite of the habitual consumption of sweetness without energy however, are yet to be investigated.

Table 2.1: Review of Recent Research Investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy

Reference	Participants ** ***	Stimuli	Comparison S/ E/ S-E *	Subjective Ratings	Perceived Pleasantness	Physiological Measures	Food Intake
Abdullah, Chabert and Louis-Sylvestre (1997)	12 males	A - 3g sucrose tablet B - 3g polydextrose tablet + 18mg aspartame C - 3g polydextrose tablet	S (C vs. B)	not measured	not measured	↔ plasma insulin ↔ glucagon ↔ glucose ↔ free fatty acids	not measured
			E (B vs. A)	not measured	not measured	↔ plasma insulin ↔ glucagon ↔ glucose ↔ free fatty acids	not measured
			S-E			**↔ plasma insulin** **↔ glucagon** **↔ glucose** **↔ free fatty acids**	
Reid and Hammersley (1995)	31 males, 29 females,	A - 568ml orange drink + 40g sucrose (160 kcal) B - 568ml orange drink + 4.34g saccharin (10 kcal) C - 568ml water	S (C vs. B)	not measured	not measured	not measured	unfixed delay ↔ time delay ↔
			E (B vs. A)	not measured	not measured	not measured	unfixed delay ↔ time delay ↑
			S-E	not measured	not measured	not measured	**unfixed delay ↔** **time delay ↔/↓**
Teff, Devine and Engelman (1995)	15 males, 16 males, fasted (Exposure - BS)	A - water (expectorated) B - aspartame solution (expectorated) C - saccharin solution (expectorated) D - sucrose solution (expectorated) E - apple pie (sham feed) (1 and 3 min exposure)	S (A vs. B, C, D)	not measured	not measured	↔ plasma insulin ↔ glucose	not measured
			S-E			**↔ plasma insulin** **↔ glucose**	

↑ = increase in appetite, ↔ = no effects on appetite, ↓ = decrease in appetite

* comparisons demonstrate S - effects of Sweetness (sweet vs. not sweet); E - effects of Energy (energy vs. no energy); or S-E - effects of Sweetness Uncoupled from Energy. Effects of Sweetness Uncoupled from Energy are included as a combination of the effects on Sweetness and the effects of Energy in studies where this is applicable.

** all participants were adults, of normal B.M.I., and following a typical unrestrained eating pattern unless otherwise stated.

*** all studies are repeated measures unless otherwise stated as Between Subjects - (BS).

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Black, Tham and Citron (1994) (abstract only)	28 males	A - 280ml carbonated water (0 kcal) B - 280ml carbonated water + 60g sucrose (~220 kcal) C - 280ml carbonated water + maltodextrin (~220 kcal) D - 280ml carbonated water + 340mg aspartame (~3 kcal)	S (A vs. D) S (B vs. C)	↔ ↔	not measured not measured	not measured not measured	~1hr delay ↔ ~1hr delay ↔
			E (A vs. C) E (B vs. D)	↓ ↓	not measured not measured	not measured not measured	~1hr delay ↓ ~1hr delay ↓
			S-E	↔			**~1hr delay** ↔
Guss, Kissileff and Pi-Sunyer (1994)	16 females (Timing - BS)	A - 500ml mineral water (0 kcal) B - 500ml water + 1% glucose + 250mg aspartame (~20 kcal) C - 500ml water + 1% fructose (~20 kcal) D - 500ml water + 10% glucose + 147mg aspartame (~200 kcal) E - 500ml water + 10% fructose (~200 kcal)	S (A vs. B) S (A vs. C)	↔ ↔	not measured not measured	not measured not measured	30 min delay ↑ 135 min delay ↓ 30 min delay ↑ 135 min delay ↔
			E (B vs. D) E (C vs. E)	↓ ↓	not measured not measured	not measured not measured	30 min delay ↓ 135 min delay ↔ 30 min delay ↓ 135 min delay ↔
			S-E	↔			**30 min delay** ↑ **135 min delay** ↔/↓
Black, Leiter and Anderson (1993)	18 males	A - 280ml carbonated water B - 560ml carbonated water C - 280ml carbonated water + 340mg aspartame encapsulated D - 280ml carbonated water + 340mg aspartame E - 560ml diet soda	S (A vs. D) S (B vs. E)	↑ ↔	foods ↓ foods ↔	not measured not measured	1hr delay ↔ 1hr delay ↔
			S-E	↑ / ↔	**foods** ↓ / ↔		**1hr delay** ↔

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Black, Tanaka, Leiter and Anderson (1991)	20 males	A - 280ml carbonated water B - 280ml flavoured diet soft drink (165mg aspartame) (2min consumption) C - 280ml flavoured diet soft drink (165mg aspartame) (10min consumption) D - 560ml flavoured diet soft drink (330mg aspartame) (10min consumption)	S (A vs. B)	↔	foods ↔	not measured	1hr delay ↔
			S-E	↔	**foods ↔**		**1hr delay ↔**
Canty and Chan (1991)	2 males, 18 females	A - 200ml water (0 kcal) B - 200ml cherry flavoured drink + 20g sucrose (~80 kcal) C - 200ml cherry flavoured drink + 112mg aspartame (~3 kcal) D - 200ml cherry flavoured drink + 67.5mg saccharin (0 kcal)	S (A vs. C)	↔	not measured	not measured	1hr delay ↔
			S (A vs. D)	↔	not measured	not measured	1hr delay ↔
			E (D vs. B)	↔	not measured	not measured	1hr delay ↔
			E (C vs. B)	↔	not measured	not measured	1hr delay ↔
			S-E	↔			**1hr delay ↔**
Rodin (1990)	4 males, 4 females, 6 males overweight, 6 females overweight, fasted	A - 500ml lemon flavoured water + 50g fructose (197 kcal) B - 500ml lemon flavoured water + 50g glucose (197 kcal) C - 500ml lemon flavoured water + 0.25g aspartame (3.7 kcal) D - 500ml unflavoured water (0 kcal)	S (D vs. C)	not measured	not measured	↔ plasma glucose ↔ insulin ↔ glucagon ↔ free fatty acids	38 min delay ↔
			E (C vs. A)	not measured	not measured	↔ plasma glucose ↔ insulin ↔ glucagon ↔ free fatty acids	38 min delay ↔
			E (C vs. B)	not measured	not measured	↑ plasma glucose ↑ insulin ↑ glucagon ↔ free fatty acids	38 min delay ↔
			S-E			**↔ plasma glucose** **↔ insulin** **↔ glucagon** **↔ free fatty acids**	**38 min delay ↔**

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Rogers, Pleming and Blundell (1990)	6 males, 6 females,	A - 200ml water + 1.2g cornflour encapsulated B - 200ml water + 1.2g cornflour encapsulated + 234mg aspartame C - 200ml water + 234mg aspartame encapsulated	S (A vs. B) S (C vs. B)	not measured not measured	sweetness ↔ sweetness ↔	not measured not measured	1hr delay ↔ 1hr delay ↑
			S-E		**sweetness ↔**		**1hr delay ↔/↑**
	10 males, 5 females,	A - 200ml water + 235mg cornflour encapsulated B - 200ml water + 235mg cornflour encapsulated + 235mg aspartame C - 200ml water + 235mg aspartame encapsulated D - 200ml water + 470mg aspartame encapsulated	S (A vs. B)	↔	not measured	not measured	1hr delay ↔
			S-E	↔			**1hr delay ↔**
Tordoff and Alleva (1990)	60 males, 60 females, (BS)	A - no chewing gum B - chewing gum - 0% aspartame C - chewing gum - 0.05% aspartame D - chewing gum - 0.3% aspartame E - chewing gum - 0.5% aspartame F - chewing gum - 1% aspartame	S (B vs. C, D, E or F)	↑ (males > D, E) (females > C)	not measured	not measured	not measured
			S-E	↑			
Birch, McPhee and Sullivan (1989)	10 males, 14 females, children (4-5.5 yrs) (Timing - BS)	A - 205ml water B - 205ml fruit flavoured drink + ~20g sucrose (90 kcal) C - 205ml fruit flavoured drink + 140mg aspartame (3.5 kcal) D - 205ml fruit flavoured drink + 140mg aspartame + 200g maltodextrin (90 kcal)	S (A vs. C)	not measured	not measured	not measured	overall ↔ 0 min delay ↔ 30 min delay ↓ 60 min delay ↔
			E (C vs. B) E (C vs. D)	not measured not measured	not measured not measured	not measured not measured	overall ↓ 0 min delay ↓ 30 min delay ↔ 60 min delay ↓ overall ↓ 0 min delay ↓ 30 min delay ↓ 60 min delay ↓

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Birch, McPhee and Sullivan (1989)	continued from above	continued from above	**S-E**				**overall ↔** **0 min delay ↔** **30 min delay ↓** **60 min delay ↔**
	7 males, 13 females, children (2-4 yrs)	A - 150ml water B - 150ml fruit flavoured drink + ~15g sucrose (60 kcal) C - 150ml fruit flavoured drink + 105mg aspartame (2.5 kcal) D - 150ml fruit flavoured drink + 105mg aspartame + 150g maltodextrin (60 kcal)	S (A vs. C)	not measured	not measured	not measured	overall ↓ 0 min delay ↔ 30 min delay ↓ 60 min delay ↔
			E (C vs. B)	not measured	not measured	not measured	overall ↓ 0 min delay ↓ 30 min delay ↓ 60 min delay ↔
			E (C vs. D)	not measured	not measured	not measured	overall ↓ 0 min delay ↓ 30 min delay ↓ 60 min delay ↓
			S-E				**overall ↓** **0 min delay ↔** **30 min delay ↓** **60 min delay ↔**
Carlson and Shah (1989)	8 males, 8 females,	A - 700ml salt solution + 0.534g aspartame B - solution + 0.534g aspartame (expectorated) C - 700ml salt solution + 0.534g aspartame encapsulated D - 700ml salt solution + 0.242g aspartic acid encapsulated E - 700ml salt solution + 0.3g phenylalanine encapsulated F - 700ml salt solution + 1.0g phenylalanine encapsulated	S (C, vs. A, B)	not measured	not measured	↔ phenylalanine ↔ insulin ↔ glucose	not measured
			S-E			**↔ phenylalanine** **↔ insulin** **↔ glucose**	

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Rogers and Blundell (1989)	6 males, 18 females,	A - 210g yoghurt + 25g fruit (131 kcal) B - 210g yoghurt + 25g fruit + 163mg saccharin (131 kcal) C - 170g yoghurt + 25g fruit + 50g maltodextrin (295 kcal) D - 170g yoghurt + 25g fruit + 50g sucrose (295 kcal) E - 170g yoghurt + 25g fruit + 50g maltodextrin + 163mg saccharin (295 kcal)	S (A vs. B)	↑	not measured	not measured	1hr delay ↑ subsequent ↑
			S (C vs. D)	↑	not measured	not measured	1hr delay ↔ subsequent ↔
			S (C vs. E)	↔	not measured	not measured	1hr delay ↔ subsequent ↔
			E (A vs. C)	↓	not measured	not measured	1hr delay ↓ subsequent ↔
			E (B vs. D)	↓	not measured	not measured	1hr delay ↓ subsequent ↔
			E (B vs. E)	↓	not measured	not measured	1hr delay ↓ subsequent ↔
			S-E	↑/↔			**1hr delay ↔/↑** **subsequent ↔/↑**
Rogers, Carlyle, Hill and Blundell (1988)	4 males, 7 females,	A - 200ml water + 145mg saccharin (0 kcal) B - 200ml water + 162mg aspartame (3 kcal) C - 200ml water + 240mg acesulfame-K (0 kcal) D - 200ml water + 50g sucrose (188 kcal) E - 200ml water (0 kcal)	S (E vs. A)	↔	foods ↑	not measured	1hr delay ↔
			S (E vs. B)	↑	foods ↑	not measured	1hr delay ↔
			S (E vs. C)	↔	foods ↔	not measured	1hr delay ↔
			E (A vs. E)	↓	foods ↓	not measured	1hr delay ↔
			E (B vs. E)	↓	foods ↓	not measured	1hr delay ↔
			E (C vs. E)	↓	foods ↔	not measured	1hr delay ↓
			S-E	↔ / ↑	**foods ↑ / ↔**		**1hr delay ↔**
Bruce, Storlein, Furler and Chisholm (1987)	5 males, fasted	A - 15ml water B - 15ml water + 38mg aspartame	S (A vs. B)	not measured	not measured	↔ blood glucose ↔ insulin	not measured
			S-E			**↔ blood glucose** **↔ insulin**	

Table 2.1: Review of Recent Research investigating the Effect on Appetite of a Single Consumption of Sweetness Uncoupled from Energy continued

Reference	Participants	Stimuli	Comparison	Subjective	Pleasantness	Physiological	Food Intake
Bruce, Storlein, Furler and Chisholm (1987)	7 males, fasted	A - tease meal + unflavoured gum + 10ml water B - tease meal + 19mg aspartame flavoured gum + 10ml water + 19mg aspartame	S (A vs. B)	not measured	not measured	↓ blood glucose ↑ insulin ↔ C - peptides ↔ free fatty acids	not measured
			S-E			**↓ blood glucose** **↑ insulin** **↔ C - peptides** **↔ free fatty acids**	
Blundell and Hill (1986)	95 males and females	A - 200ml water (0 kcal) B - 200ml water + 165mg aspartame (3 kcal) C - 200ml water + 50g glucose (188 kcal)	S (A vs. B)	↑	sweetness ↓	not measured	not measured
			E (B vs. C)	↓	sweetness ↓	not measured	not measured
			S-E	↑	**sweetness ↓**		
Brala and Hagen (1983)	52 males, 62 females, fasted, (BS)	A - 240ml flavoured milk (198 kcal) B - 240ml flavoured milk + 0.6g aspartame (198 kcal) C - 240ml flavoured milk + 60g sucrose (429 kcal) D - 240ml flavoured milk + Gymnemic Acid (198 kcal) E - 240ml flavoured milk + 0.6g aspartame + Gymnemic Acid (198 kcal) F - 240ml flavoured milk + 60g sucrose + Gymnemic Acid (429 kcal)	S (A vs. B)	↔	↔	not measured	1hr 30 min delay ↔
			S (E vs. B)	↔	↔	not measured	1hr 30 min delay ↑ sweet foods ↑
			S (F vs. C)	↔	↔	not measured	1hr 30 min delay ↑ sweet foods ↑
			E (B vs. C)	↔	↔	not measured	1hr 30 min delay ↔
			E (E vs. F)	↔	↔	not measured	1hr 30 min delay ↔
			S-E	↔	↔		**1hr 30 min delay ↑/↔** **sweet foods ↑**
Kun and Horvath (1948)	no information	A - 80ml water B - 80ml water + 0.05g saccharin	S (A vs. B)			↓ blood glucose	
			S-E			**↓ blood glucose**	

Table 2.2: Review of Recent Research Investigating the Effect on Appetite of the Repeated Consumption of Sweetness Uncoupled from Energy

Reference	Participants ** ***	Stimuli	Repetition	Comparison S/E/S-E *	Subjective Ratings	Food Intake	Body Weight
Lavin, French and Read (1997)	14 females, moderately restrained	A - 330 ml sucrose-sweetened lemonade (82.5 kcal) B - 330ml aspartame-sweetened lemonade (2.5 kcal) C - 330ml carbonated water	4 repetitions on 1 day, ~ 2hrs apart	S (C vs. B)	day 1 ↔ following day not measured	2hr delay ↔ end of day ↔ following day ↑	not measured
				E (B vs. A)	day 1 ↔ following day not measured	2hr delay ↓ end of day ↓ following day ↓	not measured
				S-E	**day 1 ↔**	**2hr delay ↔** **end of day ↔** **following day ↑**	
Mattes (1990)	12 males, 12 females	A - plain cereal breakfast (444 kcal) B - sucrose cereal breakfast (444 kcal) C - aspartame cereal breakfast (444 kcal)	5 repetitions per day, for 5 days	S (A vs. B)	mean over 5 days ↔	mean over 5 days ↔	not measured
Tordoff and Alleva (1990)	21 males, 9 females	A - 300ml aspartame-sweetened soda (1 kcal B - 300ml high fructose corn syrup-sweetened soda (160 kcal) C - no drink	4 repetitions per day, for 21 days	E (A vs. B)	not measured	end of 21 days ↔	end of 21 days ↑
Addington, PhD thesis (1988)#	70 women (BS)	A - 12oz water B - 12oz fruit flavoured drink + 240-280mg aspartame (4 kcal) C - 12oz fruit flavoured drink + 50g sucrose (200 kcal)	1 repetition per day, for 20-30 days	S (A vs. B)	↑ overall ↑ high CHO foods	overall - not measured ↑ sweet foods	↔
				E (B vs. C)	↓ overall ↓ high CHO foods	overall - not measured ↓ sweet foods	↔
				S-E	**↑ overall** **↑ high CHO foods**	**↑ sweet foods**	↔

↑ = increase in appetite, ↔ = no effects on appetite, ↓ = decrease in appetite

* comparisons demonstrate S - effects of Sweetness (sweet vs. not sweet); E - effects of Energy (energy vs. no energy); or S-E - effects of Sweetness Uncoupled from Energy. Effects of Sweetness Uncoupled from Energy are included as a combination of the effects on Sweetness and the effects of Energy in studies where this is applicable.

** all participants were adults, of normal B.M.I., and following a typical unrestrained eating pattern unless otherwise stated.

*** all studies are repeated measures unless otherwise stated as Between Subjects - (BS).

Part of this research is published as Addington and Grunewald (1988)(abstract)

Chapter 3.

UNCOUPLING SWEETNESS AND ENERGY - HABITUAL CONSUMPTION

Uncoupling sweetness and energy, the consumption of artificial sweeteners or the consumption of sweetness without energy, may have a profound effect on appetite. Studies on the single and repeated consumption of sweetness without energy show sweetness uncoupled from energy can stimulate appetite. The effects on appetite of the habitual consumption of sweetness without energy however remain uninvestigated. Such effects may be of considerable interest to the habitual high consumer of artificial sweeteners. The habitual consumer of artificial sweeteners is typically consuming artificial sweeteners as a means to maintain low levels of consumption.

The habitual consumption of sweetness without energy may have a number of possible effects on appetite and appetite control. This chapter aims to discuss these possibilities. Effects of the habitual consumption of sweetness without energy are unlikely to be a simple extension of effects of the single consumption of sweetness without energy. In single consumption, all effects on appetite are achieved as a result of the uncoupling of sweetness and energy. In habitual consumption, effects may be achieved as a result of the habitual uncoupling of sweetness and energy, and may be similar or different to the effects on appetite of the single uncoupling of sweetness and energy; or may also be achieved as a result of associations with the habitual nature of the consumption. Possible effects of the habitual high consumption of sweetness without energy on appetite and appetite control may be achieved as a result of the uncoupling of sweetness and energy, the habitual consumption of sweetness, the habitual consumption of less energy, or the habitual consumption of artificial sweeteners. Many of these possibilities will subsequently be explored in this thesis. These possibilities however are not hypotheses and will not subsequently be tested. Rather, these possibilities will be considered as potential explanations following all investigatory findings.

3.1. POSSIBLE EFFECTS ON APPETITE: THE UNCOUPLING OF SWEETNESS AND ENERGY

Effects of the habitual consumption of sweetness without energy on appetite and appetite control may firstly be achieved by the uncoupling of sweetness and energy. With reference to the effects of the single consumption of sweetness without energy (see Chapter 2), the effects of the habitual consumption of sweetness without energy on appetite will depend on the effects of the habitual consumption of sweetness without energy on the sweetness-energy relationship. Possible effects of the habitual consumption of sweetness without energy on the sweetness-energy relationship can be suggested considering the underlying mediators of the sweetness-energy relationship - cephalic phase reflexes and associative conditioning.

3.1.1. CEPHALIC PHASE REFLEXES

Cephalic phase reflexes exist as reflex responses to the sight, smell, taste and expectation of food (Teff, 1994). As reflex responses, these responses are considered to be automatic, are likely to be innate or biologically predetermined and are likely to be very inadaptable (Carlson, 1986). Whilst differences in responses have been found both within and between individuals (see Teff, 1994), no evidence is currently available suggesting a short term adaptability in cephalic phase reflex responses (Teff, 1994). By cephalic phase reflex mediation thus, the habitual consumption of sweetness without energy can be expected to have no effects on the sweetness-energy relationship, the sweetness-energy relationship will persist. Effects on appetite will be very similar to those of a single consumption of sweetness without energy. On the habitual consumption of sweetness without energy however, the sweetness-energy relationship will be often (habitually) invalid. The effects on appetite of the sweetness-energy relationship when often incorrect, can be suggested:

If the Sweetness-Energy Relationship Persists, but is Often Incorrect:

On consumption of sweetness with energy, energy is anticipated, arrives and hunger is reduced. On consumption of sweetness without energy however, as discussed in Chapter 2, energy is anticipated, does not arrive, and appetite increases. The habitual consumption of sweetness without energy would be expected to result in the habitual experience of increases in appetite, resulting either in increased eating and possibly overeating, or in the increased use of non-biological controls of appetite.

3.1.2. ASSOCIATIVE CONDITIONING

Associative conditioning, refers to the learning of an association by classical and instrumental processes (Mackintosh, 1974). Unlike cephalic phase reflex responses however, this learning is adaptable and associations can be continually learnt and relearnt to the advantage of the learning organism (Garcia, Hankins and Rusiniak, 1974). The learning and maintenance of an association however, depends on the reliability of that association. The habitual consumption of sweetness without energy will severely question and may undermine the reliability of the sweetness-energy relationship. An alteration in the reliability of the sweetness-energy relationship may result in changes in that relationship.

Possible changes in the sweetness-energy relationship can be suggested with reference to associative conditioning theory. Associative conditioning theory however, is very complex and may be influenced by a great many variables, particularly in considering conditioning paradigms in the natural world. Furthermore, due to the varying extent and influence of such a variety of variables, possible changes in the sweetness-energy relationship can only be suggested and can not be predicted. Outcomes will be specific to an individuals conditioning history. Possible changes in the sweetness-energy relationship are discussed here using only the very basic principles of associative conditioning theory.

3.1.2.1. Possible Changes In The Sweetness-Energy Relationship

By associative conditioning, the possible effects of the habitual consumption of sweetness without energy on the sweetness-energy relationship are:

- the relationship persists, but is often incorrect (sweetness → energy);
- the relationship is extinguished (sweetness ↛ energy). Learnt cue-consequence associations can be extinguished if cue and consequence are no longer reliably associated (Klein, 1996). If sweetness is not reliably associated with the physiological effects of energy, the association between sweetness and energy may be extinguished;
- the relationship is replaced by a new relationship (sweetness → no energy). Learnt cue-consequence associations can be overlearnt, if the cue, consequence or the relationship between them changes (Klein, 1996). If the taste of sweetness is reliably associated with no subsequent energy, this relationship could replace the natural sweetness-energy association.

3.1.2.2. The Probability Of Changes In The Sweetness-Energy Relationship - Classical Conditioning Principles

Based on classical conditioning principles, the likelihood of each of these results occuring depends predominantly on three factors (Klein, 1996; Garcia, Hankins and Rusiniak, 1974):

The Strength of the Initial Sweetness-Energy Association:

The stronger the initial cue-consequence association and the stronger the consequent conditioned response, the greater the likelihood of the persistence of the association (Klein, 1996). Having been learnt from birth and continually strengthened by the consumption of foods containing natural sugars, the association between sweetness and energy is strong (Blundell and Rogers, 1994). The association will also be continually experienced by the consumption of any food items containing sweetness and energy (regardless of the actual source of that energy) (Blundell, Rogers and Hill, 1988b). A strong association and a consequent strong conditioned response, the sweetness-energy relationship thus is likely to persist. Extinction of the relationship would depend on a weak initial learning of the sweetness-energy relationship. This could be achieved however, by the habitual consumption of sweetness without energy from very early in life.

The Relative Experience Of Each Association With Sweetness:

The stronger the experience of the initial cue-consequence association, the greater the likelihood of that association persisting. The greater the experience of different cue-consequence associations, the greater the likelihood of the initial association becoming extinguished (Klein, 1996). The association between sweetness and energy is experienced from birth and will be continually experienced by the consumption of any food items containing sweetness and energy (regardless of the actual source of that energy) (Blundell, Rogers and Hill, 1988b). In comparison, the association between sweetness and no energy can only be experienced in sweet-tasting foods containing no energy - artificially-sweetened beverages and artificially-sweetened gum. Other artificially sweetened foods will contain sweet taste but will also contain energy from other sources. Persistence of the sweetness-energy relationship will require the consumption frequency of sweet foods containing energy to remain greater than the consumption frequency of foods containing sweetness without energy (artificially-sweetened beverages and gum). Extinction of the sweetness-energy relationship will require the consumption frequency of artificially-sweetened beverages and gum to be close to the consumption frequency of all other sweet food items. Sweetness will not be experienced only in association with no energy. The natural association between sweetness and energy will not be replaced by a new relationship where sweetness is associated with no energy.

The Duration Of Experience Of Sweetness With And Without Energy:

The longer the duration (time x frequency) of experience of the cue-consequence association, the greater the likelihood of the persistence of that relationship. The longer the duration of a conditioned cue alone, the greater the likelihood of an extinction of the consequent conditioned response (Klein, 1996). In the sweetness-energy relationship, the longer the duration of experience of sweetness with energy, the greater the likelihood of a persistence of the relationship, the longer the duration of experience of sweetness without energy, the greater the likelihood of extinction of the sweetness-energy relationship. Experienced from birth and continually experienced (time x frequency), the sweetness-energy association thus, is likely to persist. Extinction of the association would require the experience of sweetness without energy over a long duration (time x frequency) - the frequent and habitual slow sipping of artificially-sweetened beverages or the frequent and habitual long chewing of artificially-sweetened gum.

3.1.2.3. The Probability Of Changes In The Sweetness-Energy Relationship - Instrumental Conditioning Principles

Based on instrumental conditioning principles, the consumption of sweetness is maintained by the positive aspects of the consequent physiological effects of energy - satiety. The consumption of sweetness without energy however will result in the absence of this reinforcement.

The effects on a learned behaviour and a learned association in the absence of reinforcement depend basically on the schedule of the reinforcement used to maintain the behaviour and association (Klein, 1996). A constant extinction of reinforcement will result in the constant extinction of a behaviour and an association. Intermittent extinction of reinforcement however, will result in the unlikely extinction of a behaviour or an association (Klein, 1996). Maintenance of the consumption of sweetness and the sweetness-energy relationship will be achieved by the experience of sweetness with energy, or by the experience of sweetness with energy and the intermittent experience of sweetness without energy. Extinction of the behaviour and the association will be achieved if sweetness is never reinforced by the subsequent positive physiological effects of energy - i.e. if sweetness is only experienced without energy, or if the effects of energy are no longer reinforcing - if sweetness is consumed when full / satiated. Due to the continued consumption of foods containing natural sugars, the continued consumption of sweetness with energy from other sources and the continued consumption of sweetness at all times, extinction of the sweetness-energy relationship is unlikely. Sweetness will continue to be consumed and the sweetness-energy association will persist.

Extinction of the behaviour and association may also be considered unlikely considering general high preferences for sweetness as a taste (see Chapter 1, section 1.1.1). High preferences for sweetness as a taste however, may be reinforcing unrelated to energy. Related to the associated energy, maintenance of the behaviour and the association would be expected for all similar taste-consequence associations, and is not specific to sweetness.

3.1.2.4. Probable Changes In The Sweetness-Energy Relationship

Thus, by classical conditioning principles, the habitual consumption of sweetness without energy may realistically result either in a persistence of the sweetness-energy relationship or an extinction of that relationship. By instrumental conditioning principles, the habitual consumption of sweetness without energy will result in a continual consumption of sweetness and a persistence of the sweetness-energy relationship. A persistence and an extinction of the sweetness-energy relationship will have differing effects on appetite:

If the Sweetness-Energy Relationship Persists, but is Often Incorrect:

On consumption of sweetness with energy, satiety is anticipated, is achieved and hunger is reduced. On consumption of sweetness without energy however, as discussed in Chapter 2, satiety is anticipated, is not achieved, and appetite increases. The habitual consumption of sweetness without energy would be expected to result in the habitual experience of increases in appetite, resulting either in increased eating and possibly overeating, or in the increased use of non-biological controls of appetite.

If the Sweetness-Energy Relationship is Extinguished:

Sweetness is no longer associated with subsequent energy and feelings of satiety. Sweetness consumed without energy will have no effects on appetite. Sweetness with energy will affect appetite, but only as a result of the included energy. All energy consumed however, will be unregistered biologically until digestion. This may consequently greatly increase the chances of unrequired energy intake. If the relationship is extinguished thus, sweetness is no longer associated with energy, but sweetness is also not associated with no energy. This will result in the loss of a biological control of appetite, possibly resulting either in a less strict control of appetite or in the necessary use of other non-biological controls of appetite.

3.2. POSSIBLE EFFECTS ON APPETITE: THE HABITUAL CONSUMPTION OF SWEETNESS / LESS ENERGY

Effects of the habitual consumption of sweetness without energy on appetite and appetite control may secondly be achieved by the habitual high consumption of sweetness or by the habitual high consumption of less energy.

3.2.1. THE HABITUAL CONSUMPTION OF SWEETNESS

As previously mentioned, sweetness is a highly pleasing, inherently rewarding and highly preferred taste, and as such will be much sought after and much consumed. Much consumption may result in increases in preferences for sweetness as a result of increased exposure and increased familiarity. Increased exposure and increased familiarity have previously been suggested to increase food preferences (Pliner, Pelchat and Grabski, 1993;

Pliner, 1982). Increased preferences and appetites for sweetness were found in some of the studies previously cited (Addington, unpublished PhD thesis, 1988; Kanders, Lavin, Kowalchuk, Greenberg and Blackburn, 1988; Brala and Hagen, 1983), although not all (Blackburn, Kanders, Lavin, Keller and Whatley, 1997; Mattes, 1990; Porikos, Hesser and van Itallie, 1982). The habitual consumption of sweetness may result in high preferences for and a continued high consumption of sweetness.

Much consumption however, may also result in a gradual habituation to sweetness - a diminuation in the experience of a repetitive stimulus (Klein, 1996), and may result in a consequent increase in preferred amounts and preferred intensities of sweetness (Frijters, 1987). Habituations to sweetness however, have previously not been found both following the short-term consumption of sweetness (Frijters and Schifferstein, 1992; Rolls, 1987), and following the long-term consumption (Tepper, Hartfiel and Schneider, 1996). The habitual consumption of sweetness may result in increased preferred amounts and intensities of sweetness.

3.2.2. THE HABITUAL CONSUMPTION OF LESS ENERGY

Much research has been conducted on the effects on appetite of the consumption of less energy (see Chapter 2). This research however is inconclusive. Reduced energy diets have been found to have little effect on subsequent appetite (van Itallie, Yang and Porikos, 1988; Porikos, Hesser and van Itallie, 1982) and to facilitate weight reduction (Blackburn, Kanders, Lavin, Keller and Whatley, 1997; Morris, Cuneo, Stuart, Mance, Bell, Puleo, Ahmadi, Warde and Ripp, 1993; Kanders, Blackburn; Lavin, Whatley and Pontes, 1980; Kanders, Lavin, Kowalchuk, and Blackburn, 1980); but have also been found to increase appetite (Evans, 1989; Foltin, Fischman, Emurian and Rachlinski, 1988) and to have little effect on weight reduction (Gatenby, Aaron, Jack and Mela, 1997). In some cases, the compensation for missing energy is almost complete (Foltin, Fischman, Emurian and Rachlinski, 1988). The high consumption of less energy may result in increases in appetite, though no effects are equally likely.

3.3. POSSIBLE EFFECTS ON APPETITE: THE HABITUAL CONSUMPTION OF ARTIFICIAL SWEETENERS

Effects of the habitual consumption of sweetness without energy on appetite and appetite control may also be achieved by the habitual high consumption of artificial sweeteners, by the knowledge of that consumption, and by association with the active self-selection of that consumption.

3.3.1. THE HABITUAL CONSUMPTION OF ARTIFICIAL SWEETENERS

Firstly, artificial sweeteners are all chemical compounds (A.D.A. Report, 1993), and as such if ingested may affect the physiology of the human body (see Chapter 2, section 2.2.4.1). Studies on the habitual consumption of artificial sweeteners however have so far found no evidence of long term chemical accumulation (Spiers, Saboujian, Reiner, Myers, Wurtman and Schomer, 1998; Stegink, Filer, Bell, Ziegler and Tephly, 1989) and no evidence of long term effects on appetite (A.D.A. Report, 1993). Secondly, artificial sweeteners typically replace natural sweeteners or sugars (Alexander and Tepper, 1995). As a consequence, the percentage of carbohydrate consumed in foods and in the overall diet is reduced, and in contrast percentage fat in the diet may be increased (Department of Health, 1996). In the literature previously cited, this increase in percentage fat in the diet is clearly demonstrated by Naismith and Rhodes (1995) and Porikos, Hesser and van Itallie (1982), but is also not supported by other studies (Blackburn Kanders, Lavin, Keller and Whatley, 1997; Gatenby, Aaron, Jack and Mela, 1997; Lavin, French and Read, 1997; Smith and Heybach, 1988; Parham and Parham, 1980). The high consumption of artificial sweeteners may lead to increases in fat consumption and preferences.

3.3.2. THE HABITUAL CONSUMPTION OF ARTIFICIALLY-SWEETENED BEVERAGES

The habitual high consumption of artificial sweeteners often involves the consumption of artificially-sweetened beverages. Much consideration has been given in the animal literature to the possibility that artificially-sweetened solutions may affect appetite by their osmotic properties (e.g. Tordoff, 1988a; Tordoff, 1988b). Artificially-sweetened beverages are typically hypotonic solutions. The habitual consumption of a hypotonic solution can result in overhydration and this overhydration can subsequently increase food intake (Tordoff, 1988a; Tordoff, 1988b). Evidence for increases in appetite in humans as a result of overhydration however, is currently very sparse (Tordoff, 1988b).

3.3.3. KNOWLEDGE OF THE HABITUAL CONSUMPTION OF ARTIFICIAL SWEETENERS

Cognitive variables can have great impact on appetite and appetite control (e.g. see Rozin, 1993). The knowledge of the consumption of artificial sweeteners in the short term has been reported to have great effects on appetite (e.g. Mattes, 1990). On a small scale, knowledge of the consumption of artificial sweeteners may lead to an active compensation for the known missing energy in consumption, demonstrated as a subsequent increased consumption of foods (Mattes, 1990) or increased consumption of 'naughty' rewards and treats (Polivy, 1996). On a grander scale, this reduced consumption and active compensation may easily develop into binge-eating or bulimia (Polivy, 1996). Effects of knowledge however, are not always found (e.g. Lavin, French and Read, 1997; Wardle, 1987b). Knowledge of the habitual consumption of artificial sweeteners may lead to increases in compensatory food intake and a tendency toward disordered eating.

3.3.4. SELF-SELECTION OF THE HABITUAL CONSUMPTION OF ARTIFICIAL SWEETENERS

As mentioned previously, the habitual high consumption of artificial sweeteners is usually the result of a conscious decision: consumers are actively choosing to consume artificial sweeteners (Alexander and Tepper, 1995). The active and deliberate self-selection of artificial sweeteners is reported to be associated with high levels of weight and high levels of concern over weight (Alexander and Tepper, 1995; Nabors and Lemieux, 1993). High weights and concern over weight can have strong effects on appetite and appetite control.

High levels of weight can result in increases in appetite, as a result of an increased basal metabolic rate (see Mela and Rogers, 1998), or as a result of an increased energy expenditure in performing normal everyday tasks, due to the increased metabolic costs associated with a greater body size (Prentice, Goldberg, Murgatroyd and Cole, 1996).

High levels of concern over weight can result in strong increases in appetite control, particularly the cognitive control of appetite. Increases in cognitive appetite control can have a number of differing effects on appetite (e.g. see Mela and Rogers, 1998; Gorman and Allison, 1995). Highly restrained eating has previously been suggested to be associated with a reduced intake and decreases in appetite (see de Castro, 1995). Increases in cognitive appetite control however, have also been closely associated with periodic increases in food intake and in appetite (see Wardle, 1987a, Polivy and Herman 1985), particularly when normal cognitive appetite controls can not be exercised - the overeating once normal constraints on appetite have been relaxed frequently termed 'disinhibition' (Herman and Mack, 1975). Restraint and disinhibition however are not necessarily found in relation (e.g. see Stunkard and Messick, 1985), or have been found in differing relationships in differing individuals (e.g. Westerterp-Plantenga, Kempen and Saris, 1998; Lowe, 1993). The high cognitive control of appetite can have a number of effects on intake and appetite, depending it is currently suggested, on the rigidity of that control (see Lowe, 1993; Westenhoefer and Pudel, 1993). Effects of the high cognitive control of appetite on appetite are very complex and are currently far from clearly understood.

A high cognitive control of appetite can also have a number of effects on appetite by association with other means of appetite control. A high cognitive control of appetite may be associated with high levels of physical activity (e.g. Schoeller, Shay and Kushner, 1997). High levels of physical activity can result in increases in appetite (e.g. King and Blundell, 1995). Highly cognitively controlled eating has also been previously associated with high levels of emotional eating and high levels of external eating (e.g. van Strien, Frijters, Bergers and Defares, 1986). Emotional and external eating have previously been associated with increases in food intake and difficulties in appetite control (e.g. Blair, Lewis and Booth, 1990; Schlundt, Hill, Sbrocco, Pope-Cordle, and Kasser, 1990).

3.4. SUMMARY

In summary, the habitual consumption of sweetness without energy may have a number of possible effects on appetite and appetite control. Effects may result from the uncoupling of sweetness and energy, the habitual consumption of sweetness, the habitual consumption of less energy, the habitual consumption of artificial sweeteners, the knowledge of that consumption and from associations with the active self-selection of that consumption.

Chapter 4.

THESIS OBJECTIVES

4.1. OVERALL OBJECTIVE OF THIS THESIS

In the natural world, sweetness as a taste can exert effects on appetite by virtue of its taste, its energy content, and by virtue of the reliable relationship between the taste of sweetness and the subsequent physiological effects of the energy. With the development of artificial sweeteners however, sweetness and energy can be effectively uncoupled. Uncoupling sweetness and energy, the consumption of artificial sweeteners, or the consumption of sweetness without energy may have a number of effects on appetite. The single consumption of sweetness without energy has previously been widely investigated. As demonstrated in Chapter 2, the single consumption of sweetness without energy can result in appetite stimulation. The habitual consumption of sweetness without energy however remains uninvestigated. Uncoupling sweetness and energy, the habitual consumption of sweetness without energy or the habitual consumption of artificial sweeteners may have profound effects on appetite. This thesis aims to investigate the uncoupling of sweetness and energy by the habitual consumption of artificial sweeteners.

The overall objective of this thesis is:

- to investigate uncoupling sweetness and energy in habitual high consumers of artificial sweeteners: effects on appetite and appetite control.

4.2. SPECIFIC OBJECTIVES OF THIS THESIS

The uncoupling of sweetness and energy in habitual high consumers of artificial sweeteners, or more accurately habitual high consumers of sweetness without energy, will be investigated by the comparison of habitual high consumers of sweetness without energy with habitual low consumers. High and low consumers of sweetness without energy however, are only found in the natural world in high and low consumers of artificially-sweetened beverages or high and low consumers of artificially-sweetened gum. The habitual consumption of sweetness without energy in this thesis will thus be investigated by comparison of habitual high and low consumers of artificially-sweetened beverages or artificially-sweetened gum. Habitual high and low consumers of artificially-sweetened beverages and gum will be defined using population consumption levels of artificially-sweetened beverages and artificially-sweetened gum. (Note: Due to the concurrent consumption of sweetness with energy, the habitual high consumption of artificially-sweetened beverages and gum will result in the habitual, but only partial uncoupling of sweetness and energy).

Effects on appetite will be investigated using highly controlled laboratory-based nutritional challenges. These nutritional challenges will measure subjective and behavioural responses to sweetness and energy when consumed as a drink, subjective and behavioural responses to sweetness when consumed as a meal, and subjective responses to sweetness, sweetness intensity and dietary fat levels when experienced as a drink. Effects on appetite control are widely investigated by measuring relevant attitudes and behaviours. General eating attitudes and behaviours will be measured by self-report questionnaire. Specific eating behaviours will be measured by the completion of specialized food diaries. The completed food diaries will also be used in support of some of the laboratory study outcomes.

Prior to investigation of the habitual consumption of sweetness without energy, the effects of a single consumption of sweetness without energy on appetite will be demonstrated. Effects of a single consumption of sweetness without energy on appetite are currently disputed, due to the amount of previous research reporting an absence of effects. Lack of effects however, can be attributed to the use of inappropriate methodologies. This demonstration of the effects of a single consumption of sweetness without energy on appetite will use a methodological design and procedure aimed to maximize effects and the detection of those effects.

The specific objectives of this thesis are:

- to demonstrate the effects of single consumption of sweetness without energy on appetite.
- to establish population consumption levels of artificially-sweetened beverages and gum, and to define habitual high consumers of sweetness without energy.
- to investigate the effects of the habitual consumption of sweetness without energy on appetite. This will be done by investigating:
    - responses to sweetness and energy when consumed as a drink.
    - responses to sweetness when consumed as a meal.
    - responses to sweetness, sweetness intensity and dietary fat levels, as a drink.
- to investigate the effects of the habitual consumption of sweetness without energy on appetite control. This will be done by investigating:
    - general eating attitudes and behaviours.
    - specific eating behaviours.

4.3. POTENTIAL IMPLICATIONS OF THIS THESIS

This investigation of the uncoupling of sweetness and energy in habitual high consumers of artificial sweeteners may have many implications, both theoretical and practical.

Firstly, this research will demonstrate the effects on appetite and appetite control of the habitual consumption of sweetness without energy, as achieved by the habitual high consumption of artificially-sweetened beverages. This research may be of considerable interest and benefit to the habitual high consumer of artificial sweeteners. Habitual high consumers of artificial sweeteners are typically consuming artificial sweeteners as a means to maintain low levels of consumption. The single consumption of sweetness without energy however, can stimulate appetite.

The effects on appetite and appetite control of the habitual consumption of sweetness without energy may also shed some light on the effects on appetite of the habitual uncoupling of sweetness and energy. The habitual uncoupling of sweetness and energy may be detrimental to overall appetite regulation. Increases in appetite or increases in the reliance on non-biological controls of appetite, could potentiate increases in obesity and increases in eating disturbances.

As an example of a taste-consequence association, this work on the sweetness-energy relationship will also shed some light on the effects of taste-consequence associations in appetite and appetite control, and the potential effects of similar associations if uncoupled. This may have important implications in, for example, the treatment of food-aversions and avoidances, or the treatment of addictions. By extension, this research may also cast some light on the adaptability or inadaptability of the human body.

On a smaller scale, but perhaps more directly applicable, this research may also shed some light on the effects on appetite of normal consumption patterns. If appetite and appetite control are affected by normal dietary consumption patterns - the habitual high consumption of artificially-sweetened beverages, these consumption patterns should be controlled for in all future appetite research. Differences in normal consumption patterns may explain some of the variety in effects on appetite already found.

The investigation of the uncoupling of sweetness and energy in habitual high consumers of artificial sweeteners will be potentially beneficial to the field of human appetite research. Furthermore, with the rapidly increasing consumption of artificial sweeteners by the general population, this investigation is long overdue.

Chapter 5.

THESIS METHODOLOGY

The objectives of this thesis outlined in the previous chapter, will each be investigated individually. The resulting eight studies will be described in the order of the specific objectives, in the following seven chapters. This chapter considers some of the general methodological issues relevant to these studies. Broader methodological issues have been reviewed elsewhere (e.g. Hill, Rogers and Blundell, 1995; Bingham, 1987).

5.1. PRECISION versus NATURALNESS

The major methodological issue relating to appetite research is the dilemma between 'precision' and 'naturalness' - the dilemma between the precise and accurate measurement of appetite (internal validity), and the measurement of appetite as naturally occuring within the natural environment (external validity) (Hill, Rogers and Blundell, 1995; Booth, 1992; Meiselman, 1992). Precise and accurate measurement is achieved by the use of high levels of scientific control. The effects on appetite of deliberate nutritional manipulations are measured precisely and accurately in highly controlled, uniform laboratory environments (Hill, Rogers and Blundell, 1995). The highly controlled laboratory, however, firstly may influence and contaminate data, and secondly, can provide only limited information regarding appetite in the natural environment. The measurement of appetite and appetite control as occuring in the natural environment can only be usefully investigated within that environment (Meiselman, 1992). Investigation within the natural environment provides realistic and generalizable data that is unconstrained by experimental manipulations. Measurements taken in the natural environment, however, are often imprecise and are easily confounded by extraneous variables. A complete understanding of appetite and appetite control requires the combination of both precise and natural investigation (Hill, Rogers and Blundell, 1995; Booth, 1992; Meiselman, 1992).

This thesis combines precision and naturalness, both between and within studies. Five laboratory studies, two questionnaire studies and one field study were conducted. Precise laboratory studies were made as natural as possible: by the use of commercially-available foods and drinks; by the use of realistic meals, meal-times and inter-meal-times; and by restricting the natural behaviours of the participants as little as possible. Investigation in the natural environment (questionnaire and field studies) was made as precise as possible by the use of detailed measurement tools and the adequate training of participants if required.

5.2. LABORATORY STUDIES

The laboratory studies in this thesis are studies 1, 3, 4, 5, and 6, described in chapters 6, 8, 9, and 10.

5.2.1. STUDY DESIGN

All laboratory studies were of mixed design (incorporating within- and between-subjects comparisons), excepting Study 1, which is within-subjects design.

5.2.1.1. Consumer Group and Gender

The between-subjects comparisons allowed: comparison between consumer groups - habitual high consumers of artificially-sweetened beverages and habitual low consumers; and comparison between genders. Consumer groups were compared as necessitated by the nature of the thesis. Habitual high and low consumers were defined as detailed in Study 2. In Studies 5 and 6, low consumers were also further defined, based on a potential methodological confound elucidated in Studies 3 and 4. Genders were compared due to the novel nature of this work. Differences between genders have been found previously in human appetite research (Rolls, Fedoroff and Guthrie, 1991). For both consumer group and gender, between-subjects comparisons were required due to the long-term nature of the comparisons studied. Whilst allowing inter-individual variation to possibly influence findings (Coolican, 1990), potential variation was kept as minimal as possible by the careful selection of all participants within each group. Possible influence of individual variables will also be borne in mind when considering all findings. In Study 1, all participants were low consumers and male, due to the study objectives.

5.2.1.2. Nutritional Manipulations

The within-subjects comparisons in all laboratory studies compared the effects on appetite of the nutritional components of interest. Within each study, all participants received all nutritional manipulations. The use of a within-subjects design minimizes the effects on measures of appetite of inter-individual variation (Coolican, 1990). All participants also received all manipulations in each study in a counterbalanced order, to minimize order effects. In Studies 1, 3, 4, and 6, counterbalancing was multi-conditioned to minimize asymmetrical order effects. In Study 5, multi-conditioned counterbalancing was not possible, due to the existence of only two experimental conditions. In Studies 1, 3, 4, and 5, carry-over effects were minimized by all participants receiving all nutritional manipulations at least a week apart. In Study 6, all nutritional manipulations were experienced in one half-hour, and carry-over effects were minimized by alternating the sampling of each nutritional manipulation with a sip of water. In Studies 1, 3, 4, and 5, effects due to extraneous variables were also minimized by asking all participants to keep all natural behaviour (particularly physical activity levels) as constant as possible on each study day, and to refrain from drinking alcohol the night before each study day.

5.2.2. PARTICIPANTS

All participants were defined as high or low consumers before inclusion in each laboratory study. Prior to inclusion in each study, participants were also screened as non-smokers, reported no previous adverse reactions to sugar or artificial sweeteners, were not taking any appetite-influencing medication, were not currently dieting, and liked all foods in the study. Differences in responses to appetitive stimuli have previously been demonstrated between smokers and non-smokers (e.g. Hayes, Fedkle and Garcia, 1995), and between dieters and non-dieters (e.g. Lowe, 1995). The palatability of foods can also have strong effects on appetite (e.g. Yeomans, Gray, Mitchell and True, 1997; see Rogers, 1987). Body Mass Index (B.M.I.) and Dietary Restraint were also measured prior to inclusion in any study, but were only used as screening criteria for Study 1. B.M.I. and dietary restraint were not used as screening criteria in Studies 3, 4, 5, and 6, to avoid unrepresentative sampling of either high or low consumers. High and low consumers of artificially-sweetened beverages were expected to differ in B.M.I. and dietary restraint, due to a reported association between the high consumption of artificial sweeteners and dieting (Alexander and Tepper, 1995). B.M.I. was calculated for all participants as weight (kg) / (height (m))^2. Dietary Restraint was measured in Study 1., using the Restraint Scale of the Three Factor Eating Questionnaire (T.F.E.Q.) (Stunkard and Messick, 1985) and in all other studies using the Restraint scale of the Dutch Eating Behaviours Questionnaire (D.E.B.Q.) (van Strien, Frijters, Bergers and Defares, 1986). The T.F.E.Q.-R. and D.E.B.Q.-R. are reliable, well-validated questionnaire measurements of dietary restraint. The D.E.B.Q.-R was used in the majority of studies as can be considered the more pure dietary restraint scale, composed of a single scale as opposed to several subscales (see Gorman and Allison, 1995). The T.F.E.Q. was used in Study 1, to allow comparison of the study findings with related studies (not referred to in this thesis) (King, PhD thesis, 1994). The potential effects on appetite of differences between B.M.I. and between Dietary Restraint scores were considered in all analyses (section 5.2.5). All participants in all laboratory studies were staff and students of Leeds University, and were recruited by means of poster and newspaper advertisements.

5.2.3. PROCEDURES

The effects on appetite of all nutritional manipulations were investigated using either a preloading paradigm or a taste-testing paradigm.

The preloading paradigm is a frequently used procedure in human laboratory-based appetite research (Hill, Rogers and Blundell, 1995). The nutritional component of interest is given as a precisely controlled preload manipulation, and effects on appetite are subsequently measured using subjective, physiological and/or behavioural measurements (Kissileff, 1985). The main advantage of the preloading paradigm, compared to other testing procedures, lies in the ability to infer precise causal relationships (Hill, Rogers and Blundell, 1995; Kissileff, 1985).

The taste-testing paradigm is a much reduced version of the preloading paradigm. The nutritional component of interest is given as a precisely controlled preload manipulation, but effects on appetite are only measured indirectly using subjective measurements of food preferences and expectations. Whilst limited because effects on appetite are not measured directly, the taste-testing paradigm can provide valuable information on the subtle subjective aspects of appetite which may greatly influence overt expressions of appetite, such as food intake (e.g. Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1985; Drewnowski and Greenwood, 1983).

5.2.4. MEASURES OF APPETITE

In this thesis, appetite is defined as a propensity toward consumption of foods and fluids. Appetite was measured using subjective and behavioural measures. Physiological measurements of appetite were not taken for practical reasons.

5.2.4.1. Subjective Measures

Subjective perceptions of appetite are measured using Visual Analogue Scales (V.A.S.). Participants are required to indicate the degree to which they are currently experiencing a particular dimension of appetite, by placing a mark on a continuous 100mm line anchored at each end by the two extremes of that dimension - 'not at all ___' and 'extremely ___'. This mark is converted into a V.A.S. score by measurement from the lower extreme value to the mark, to the nearest mm (de Graaf, 1993). In Studies 1, 3, 4, and 5, measurements were taken of subjective perceptions of Hunger, Desire to Eat, Fullness, Prospective Consumption, and Thirst. In Studies 3, 4, and 5, measurements were also taken for Desire to Drink. In Study 5, perceptions of Appetite for Something Sweet, Appetite for Something Savoury, and Appetite for a Meal were also measured (de Graaf, 1993). In Study 6, perceptions of Pleasantness, Saltiness, Sweetness, Prospective Fullness, and Prospective Satisfaction were measured. All V.A.S. in Studies 1 and 6, were administered by paper and pencil. All V.A.S. in Studies 3, 4, and 5, were administered by the Electronic Appetite Rating System (Delargy, Lawton, Smith, King and Blundell, 1996). The reliability of subjective measures of appetite have previously been demonstrated, but measurements can be subject to inter- and intra-individual variation (see Raben, Tagliabue and Astrup, 1995). In an attempt to minimize this variation all participants were trained in the use of V.A.S. prior to utilization. The validity of subjective measures is difficult to assess by their very nature, but subjective measures of hunger have been found to correlate well with concurrent behavioural measures of appetite (de Graaf, 1993). The specific scales used have all been used previously and have been found to be sensitive to varying appetitive challenges (e.g. Raben, Tagliabue and Astrup, 1995; de Graaf, 1993; Hill and Blundell, 1986)

5.2.4.2. Behavioural Measures

Appetite is commonly measured behaviourally by the measurement of food consumption. Predominantly, the extent of consumption is measured (e.g. weight of food consumed, energy consumed), but rate of consumption, the time delay before consumption and consumption choice are also frequently used (Hill, Rogers and Blundell, 1995). In this thesis, the extent of consumption was measured in all laboratory studies, and in Study 1 the time delay before consumption was also measured.

Accurate direct measurement of the extent of consumption is achieved in the laboratory by the ad-libitum test meal. All foods/meals are provided in excess, participants consume until they are 'comfortably full', and consumption is measured by weighing all foods pre- and post-consumption, to the nearest gram (Hill, Rogers and Blundell, 1995). The use of test meals is well-documented, but consideration must be given to the meals used. The palatability, familiarity and variety of foods available can all influence amount consumed (Blundell and Green, 1996; Hill, Rogers and Blundell, 1995). All foods used in this thesis were commercially-available foods and were liked by all participants. All meals were constructed to mimic natural meals - i.e. main course plus dessert, and were appropriate for the time of the day when served (see Kramer, Rock and Engell, 1992). All meals however were of limited selection, so limit food choice. Consumption choice was not measured in this thesis. Any effects on the extent of consumption as a result of limited choice were minimized by the use of familiar, liked and varied foods, and by testing each participant only once per week.

Accurate indirect measurement of the extent of consumption is achieved outside the laboratory by use of an ad-libitum snackbox. All foods are provided in excess and consumption is measured by weighing all foods prior to distribution, by the accurate recording of all consumption on appropriate inventories by the participants, and by weighing all returned foods and cross-checking those consumed against the inventory. All drinks consumed (not provided) were also recorded by the participants on the inventory. All snackboxes contained a variety of familiar, liked foods and were appropriate for the time of day for which they were provided. Whilst compromising control slightly, snackboxes allow the accurate recording of consumption, while constraining natural behaviour as little as possible (see Hirsch and Kramer, 1993; Meiselman, Hirsch and Popper, 1988).

Measurement of the extent of consumption is also extended outside the laboratory by the use of food diaries. All consumed foods and drinks are recorded throughout the day in a food diary (de Castro, 1994a). Portion-size food diaries were used as opposed to weighed food diaries to aid and speed completion by the participants (Wolper, Heshka, Heymsfield, 1995). To minimize recording errors, all participants were trained in the use of food diaries prior to utilization. Full consideration of the value of food diaries in appetite research is given in section 5.4.2.

In Study 1, time delay before consumption was also measured. This is a measure of the time interval between the availability of food and the start of consumption, and is considered to be a reliable measurement of appetite (e.g. King, Burley and Blundell, 1994).

5.2.5. DATA ANALYSIS

All analyses for all laboratory studies were conducted using parametric tests. The assumptions underlying the use of parametric tests (interval data, a normal distribution, homogeneity of variance) in all cases were considered to be satisfactorily met.

Subjective Measures of Appetite: For all studies excepting Study 6, subjective measures of appetite are described as temporal profiles of appetite. In Study 6, subjective measures of appetite are described as profiles of each nutritional manipulation. All subjective measures were analysed by mixed Analysis of Variance (ANOVA) or by mixed Analysis of Variance with Covariates (ANCOVA), as applicable. ANCOVA was used to accommodate differences in B.M.I. and/or D.E.B.Q.-R. scores, found between participant groups. B.M.I. and dietary restraint have previously been shown to influence appetite and appetite control (Prentice, Black, Murgatroyd, Goldberg and Coward, 1989; Lowe, 1995; Laessle, Tuschl, Kotthaus and Pirke, 1989). Student-Newman-Keuls t-tests were used to investigate all significant ANOVA/ANCOVA results. Missing data for the subjective measures of appetite were in all cases, replaced with adjusted means. (Adjusted means were calculated as, for example: adjusted mean (participant 4, condition x, time 2) = [mean(group-participant 4, condition x, time 2)] - [mean(group-participant 4, condition y, time 2) - (participant 4, condition y, time 2)]). The replacement of missing data with values was necessary due to the constraints of the statistical tests used. The use of adjusted means allowed replacement values to be as realistic as possible for each individual participant.

Behavioural Measures of Appetite: Behavioural measures of intake were analysed in

Study 1 by repeated measures ANCOVA, and in Studies 3, 4, 5, and 6, by mixed ANOVA or ANCOVA, as applicable. Student-Newman-Keuls t-tests were used to investigate all significant ANOVA/ANCOVA results. Energy intake from foods were calculated using energy conversion factors of carbohydrate = 3.75 kcal/g, fat = 9 kcal/g, and protein = 4 kcal/g. Missing data in the behavioural measurements was kept to a minimum. The data for some participants however, was discarded due to the excess consumption of alcohol. The consumption of alcohol can affect appetite (e.g. Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996; Foltin, Kelly and Fischman, 1993). Alcohol consumption was deemed possibly influential in appetite if in excess of 4 units (Foltin, Kelly and Fischman, 1993). Under 4 units, alcohol intake was included in data measurements with all other beverage intakes (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996). All missing data were acknowledged as missing by the computer - none were replaced.

All analyses were completed in SPSS for Windows.

5.3. QUESTIONNAIRE STUDIES

Questionnaire studies are naturalistic - participants report natural responses to natural circumstances - behaviours, thoughts, attitudes, etc., Compared to other naturalistic methods, the questionnaire is quick and easy to administer and complete, so allows the consideration of a large number of responses, and increases the likelihood of testing a non-biased sample (Margetts, Cade and Osmond, 1989). Questionnaires, however, do rely heavily on self-report and responses may be pre-empted, suggested, socially desirable, experimentally desirable, untrue, or may be constrained (see Coolican, 1990). To counteract these problems, in the questionnaires used in this thesis: all relevant questions were concealed amongst other related questions, only very broad indications of the purpose of the questions were given, and open responses were required when detail was needed.

The questionnaire studies in this thesis are Studies 2 and 7, described in Chapters 7 and 11. Questionnaires were also used in Study 8 and in recruiting for all laboratory studies. All questionnaires used were either food frequency questionnaires or construct questionnaires.

5.3.1. FOOD FREQUENCY QUESTIONNAIRES

Food Frequency Questionnaires (F.F.Q.) assess the frequency of consumption of a given food item in a specified time interval (Margetts, Cade and Osmond, 1989). In Study 2, a F.F.Q. was designed to assess population consumption levels of artificially-sweetened beverages and gum. This was subsequently adapted as a recruitment questionnaire to assess consumption levels of various types of beverage. The F.F.Q. is simple, easy and quick to administer, complete and score (Margetts, Cade and Osmond, 1989), but does rely heavily on memory and generalizations from memory (Livingstone, 1995).

5.3.2. CONSTRUCT QUESTIONNAIRES

Construct questionnaires measure subjective qualities - attitudes, thoughts, perceptions, as well as behaviours. Questions are typically responded to on a likert-type measurement scale and the response to each question contributes to a score on a specific construct scale. The outcome of the questionnaire per participant, is a score per construct scale (Coolican, 1990). Reliability and validity are increased by the testing of all questions, repeatedly and on several differing populations, prior to the final formulation of the questionnaire (see Schlundt, 1995; Coolican, 1990). The validity of the questionnaire however is threatened if data are missing - one piece of missing data will result in the invalidity of a whole construct scale. The problems of missing data however, unless systematic (e.g. Fairburn and Beglin, 1990) or affecting a large number of responses (Coolican, 1990), are often minimal (Schlundt, 1995).

5.3.3. DATA ANALYSIS

All questionnaires were scored manually and analysed in SPSS PC+. Description and analysis differed for all questionnaires depending on study hypotheses. All missing data were acknowledged as missing by the computer - none were replaced.

5.4. FIELD STUDIES

Field studies allow the investigation of natural responses, to natural events, occuring in a natural environment. Compared to other naturalistic methods, field studies provide realistic, extensive and comprehensive data sets (de Castro, 1994), but are limited by the amount of work required both by participants and by researchers (Wolper, Heshka and Heymsfield, 1995; Bingham, 1987). One field study was conducted in this thesis - Study 8, Chapter 12.

5.4.1. STUDY DESIGN

The field study in this thesis is of between-subjects design. The between-subjects comparisons allowed comparison between consumer groups and comparison between genders, as in all laboratory studies (section 5.2.1.1.). Participants were also selected for the study, using the same criteria as for all laboratory studies (section 5.2.2.), but were recruited from the whole of the Leeds area. The use of similar participants in the laboratory and field studies allowed limited comparison between study findings. For increased generalization of the field study findings, a larger and more diverse participant sample would be required. The data for the field study was collected by the completion of food diaries for four consecutive days. The reliability of the data collected was checked against a number of other naturalistic measures of dietary consumption.

5.4.2. FOOD DIARIES

The completion of a food diary simply involves the recording of absolutely everything consumed (de Castro, 1994a). The diaries used in this thesis were further adapted to also allow the recording of numerous situational variables and subjective reasons for meal initiation and termination. Details regarding the specific diary used are given in Chapter 12.

5.4.2.1 Under-reporting

Food diaries have previously been reported as accurate, comprehensive, reliable and valid methodological tools (see de Castro, 1994a). The data gathered by food diaries, however, rely very heavily on sustained, accurate record-keeping. The systematic inaccurate under-reporting of consumption is a serious problem in diary studies (Garrow, 1995). The problem is also highly complex (see Livingstone, 1995). Firstly, not all under-reporting is deliberate or conscious. Deliberate under-reporting can result from deliberate mis-reporting as a result of social desirability, experimental desirability, suggestion, constraints, or plain untruths (see Hebert, Clemow, Pbert, Ockene and Ockene, 1995; Bingham, 1987). Non-deliberate under-reporting can result from inabilities or inaccuracies in estimating intake quantities, memory lapses, the irritation and inconvenience of accurate reporting and from the act of recording intake, resulting simply in increases in dietary awareness, in dietary restraint and in dietary alterations (Livingstone, 1995). Secondly, under-reporting is known to differ between participants. Participant motivation, compliance and honesty are key factors in accurate reporting (Livingstone, 1995). Under-reporting has also been found to differ between participant groups. Obese individuals have frequently been found to under-report more than lean people (Heitmann and Lissner, 1995; Livingstone, Prentice, Strain, Coward, Black, Barker, McKenna and Whitehead, 1990; Prentice, Black, Murgatroyd, Goldberg and Coward, 1989), and degree of under-reporting has also been found to differ between age groups and socio-economic status (e.g. Livingstone, Prentice, Coward, Strain, Black, Davies, Stewart, McKenna, and Whitehead, 1992). Thirdly, under-reporting is also more frequent for certain food types. Foods perceived as unhealthy (cakes, chocolate, alcohol, snacks) are under-reported more often than other foods (MacDiarmid, PhD thesis, 1997; Heitmann and Lissner, 1995), and healthy foods (fruit and vegetables) may even be over-reported (MacDiarmid, PhD thesis, 1997). Under-reporting is also more likely over long time periods, and particularly in the middle sections of long time periods (Livingstone, Prentice, Strain, Coward, Black, Barker, McKenna and Whitehead, 1990).

Attempts were made in this thesis to counteract diary under-reporting. The food diaries used, firstly, required as little actual writing as possible to speed completion and reduce effort required. The food diaries used were 'portion-size' food diaries, as opposed to weighed food diaries, in order to reduce the effort required by the participants for data recording. 'Portion-size' diaries allow the increased likelihood of recording by participants, but reported quantity is less accurate than in weighed diaries (Wolper, Heshka and Heymsfield, 1995). The accuracy of reported quantity using 'portion-size' diaries was increased by fully instructing all participants on the use of household measures and food portion sizes prior to completion of the diaries. The importance of accuracy was repeatedly stressed to all participants. The completion of food diaries also lasted for only four days. Previous research suggests only 3 - 7 days of data are required to accurately measure many consumption variables (de Castro, 1994a; Bingham, 1987). To increase motivation participants were also offered detailed feedback about their diet, based on the diaries once completed, and were given a little background information into the purpose and value of the study. Full information regarding hypotheses was not given to reduce the possibility of responses due to systematic demand characteristics (Coolican, 1990). Finally under-reporting was checked for and any participant found to be grossly under-reporting in the food diaries was excluded from the study. Under-reporting was checked by comparison of the data from the diaries with: data from an F.F.Q., data from a 24-hr recall, data from a one-day diary, a calculation of B.M.R. and estimated energy expenditure, and was also questioned in a debrief questionnaire. Details of the F.F.Q. are provided in section 5.3.1. The 24-hr recall is a recollection of everything consumed in the past 24 hrs (Wolper, Heshka and Heymsfield, 1995). F.F.Q.s and 24-hr recalls are less prone to selective and deliberate under-reporting than diaries, but do rely heavily on memory so may be subject to non-deliberate under-reporting or mis-reporting (Livingstone, 1995). The one-day diary was identical to the food portion size diaries used for the study and was completed prior to the start of the study, as a 'practice' diary. F.F.Q.s, 24-hr recalls and 1-day diaries are less prone to motivation-related under-reporting than other dietary assessment methods, but measurement over such a short time period may be unrepresentative of habitual diet (Garrow, 1995). Estimated energy expenditure was calculated for each participant, based on body weight and self-reported levels of physical activity (Department of Health, 1991). Assuming all participants to be in energy balance for the period of the study, energy intake will be equal to calculated energy expenditure. Calculated energy intake is only an estimate, but was originally developed from actual intake data (see Department of Health, 1991), and will clearly indicate gross under-reporting (e.g. Prentice, Black, Murgatroyd, Goldberg and Coward, 1989). Gross under-reporting will also be indicated by comparison of mean Energy Intake and calculations of B.M.R. (Goldberg, Black, Jebb, Cole, Murgatroyd, Coward and Prentice, 1991)

The limitations of numerous naturalistic dietary assessment methods have been extensively reviewed elsewhere (e.g. Allison, 1995; Livingstone, 1995; Bingham, 1987). While attempting to counteract under-reporting, none of the methods above are free from error and none will provide absolute measurements of actual energy intake. Gross under-reporting may be detected and prevented, but in a study based on food diary data, minimal under-reporting is accepted as highly likely.

5.4.3. DATA ANALYSIS

All diary data were converted into consumption levels of energy and all macronutrients using Comp-Eat - a computerised version of McCance and Widdowson's The Composition of Foods (Holland, Welch, Unwin, Buss, Paul and Southgate, 1992), supplements to McCance and Widdowson (Chan, Brown, Church and Buss, 1996; Chan, Brown, Lee and Buss, 1995; Chan, Brown, and Buss, 1994; Holland, Brown and Buss, 1993; Holland, Welch and Buss, 1992; Holland, Unwin and Buss, 1992; Holland, Unwin and Buss, 1991; Holland, Unwin and Buss, 1989; Holland, Unwin and Buss, 1988;), and using manufacturer's information for all manufactured products. Food Portion Sizes (MAFF, 1988) was used to convert standard portion sizes into weight. All consumption data and all other data (situational variables and reasons for meal initiation and termination) were analysed in SPSS for Windows. Description and analysis depended on the study hypotheses. All missing data were acknowledged as missing by the computer - none were replaced.

5.5. ETHICS

All studies were given ethical approval by the Ethics Committee, Department of Psychology, University of Leeds. In all studies, excepting the two questionnaire studies, all participants were given full information regarding all procedural details prior to the start each study, were informed that they could cease participating in the study at any time without reason, and consented to take part in the study as required. None of the participants were told the hypotheses of any study, due to the possibility of systematic effects due to experimental demand characteristics (Coolican, 1990). All participants however, were told the general nature of each study in an attempt to elicit an interest in the study and an understanding of the importance of all instructions, so increasing compliance and study completion. At the end of each study, all participants were informed of the specific nature of that study and were offered the findings from the complete study, if they wished. All participants of all laboratory studies were also recompensed for any inconvenience caused.

Chapter 6.

STUDY 1:

THE EFFECTS OF A SINGLE CONSUMPTION OF SWEETNESS WITHOUT ENERGY ON APPETITE

6.1. INTRODUCTION

The effects of a single consumption of sweetness without energy on appetite have been widely investigated (see Renwick, 1994; Rolls, 1991). To summarize much of the previous research, the single consumption of sweetness without energy can stimulate appetite (Rogers and Blundell, 1989a). This conclusion however remains disputed. Many previous studies have failed to find any effects on appetite following sweetness without energy (e.g. Black, Tham and Citron, 1994; Black, Tanaka, Leiter and Anderson, 1991; Canty and Chan, 1991). The failure to find effects however may be a result of the use of inappropriate and insensitive methodologies (Rogers and Blundell, 1989a). The effects on appetite of sweetness without energy may be subtle, difficult to detect or easily over-ridden.

The most appropriate methodology for investigating the consumption of sweetness without energy can be inferred from Chapter 2 sections 2.1 and 2.4.4. A preloading paradigm, involving both additive and substitutive procedures, should be used (Rogers and Blundell, 1989). Preloads should differ only in sweetness and energy levels, and differences in sweetness and energy values should be as large as possible. Subsequent appetite should be measured using a number of sensitive measures of appetite (Blundell and Green, 1996). Contamination of the whole design should be kept to a minimum: biologically inert preload vehicles (or as close as possible) should be used (Tordoff, 1988a); biologically inert preload sweeteners should be used (Rolls, 1991), and participants should be unrestrained and uninformed of the experimental hypotheses, but familiar with and relaxed in the experimental situation (Rolls, 1991). Sensitivity of the design may also be increased by the use of lean, male participants (see Rolls, Castellanos, Halford, Kilara, Panyam, Pelkman, Smith and Thorwart, 1998; Rolls, Fedoroff and Guthrie, 1991).

The sensitivity of the design may also be enhanced by the addition of an exercise component. Previous research into exercise and appetite have suggested exercise to result in an increased sensitivity to bodily requirements, both in immediate response to a single exercise session (Verger, Lanteaume and Louis-Sylvestre, 1994; Verger, Lanteaume and Louis-Sylvestre, 1992), and as a long term response to regular exercise (Verger, Lanteaume and Louis-Sylvestre, 1994). This increased physiological sensitivity following an exercise session and resulting from regular exercise may also result in an increased sensitivity to nutritional manipulations.

An exercise session will also result in a loss of fluids and a depletion of energy reserves (McArdle, Katch and Katch, 1991). The immediate need for increased fluids following exercise can be arranged to allow the increased consumption of a preload (e.g. Thompson, Wolfe and Eikelboom, 1988). The need for energy repletion can be arranged to allow the high and unrestrained consumption of a test-meal.

Using an appropriate and sensitive methodology any effects on appetite of a single consumption of sweetness without energy should be clearly demonstrated.

6.1.1. AIMS

This study aims to investigate the effects of a single consumption of sweetness without energy on appetite, using an appropriate and sensitive methodology. An appropriate methodology will be achieved as suggested above. The sensitivity of the design will also be enhanced by the inclusion of a high intensity, long duration exercise session and the participation of lean, male, regular exercisers. The appropriate design however, is compromised slightly in three aspects. The use of realistic (commercially-available) and familiar preloads necessitated the use of flavoured sweet preloads, and the use of aspartame as an artificial sweetener. The inclusion of the exercise session necessitated the subsequent availability of unlimited fluids - i.e. an unlimited quantity of preload.

6.2. METHOD

6.2.1. DESIGN

The study uses a within-subjects design, investigating sweetness/energy manipulation (3 levels). The study was conducted using a preloading procedure, where sweetness/energy manipulation was given as a preload and appetite was subsequently measured using subjective and behavioural measures. A high intensity, long duration exercise session was included in the study, immediately prior to the preload.

6.2.2. PARTICIPANTS

Sixteen male regular exercisers took part in the study. All were non-smokers, were lean (B.M.I. < 25 kg/m^2), were unrestrained (T.F.E.Q.-R. score < 8), exercised at least three times a week, and liked all foods in the study. None of the participants were informed of the exact hypotheses of the study.

Prior to the start of the study, all participants also completed a standard incremental test of maximum oxygen intake - VO_2max test (see Shepard, 1984), to assess individual levels of fitness. The test was conducted on a treadmill - speed set at 6 mph, gradient increasing in increments of 2^o every 3 minutes. Participants ran to volitional exhaustion. On reaching a respiratory quotient (RQ) of > 1.15 and an increase in oxygen intake of < 2.0 ml/kg(body weight)/min, maximum volume (V) of oxygen (O_2) intake per min - VO_2max was measured (ml/kg/min) (e.g. King and Blundell, 1995; King, Burley and Blundell, 1994; Thompson, Wolfe and Eikelboom, 1988). Participant characteristics are given in Table 6.1.

Table 6.1: Participant Characteristics (mean (standard deviation))

	B.M.I. (kg/m^2)	T.F.E.Q.-R. score	VO_2max (ml/kg/min)
Participant (N=16)	22.8 (3.0)	4.4 (3.2)	51.7 (7.1)

6.2.3. SWEETNESS / ENERGY MANIPULATIONS

The sweetness / energy manipulations were given as a preload drink. The three manipulations used were:

- non-sweet / low energy - water (W) - 0 kcal/g
- sweet / low energy - artificially-sweetened drink (AS) - 0.02 kcal/g
- sweet / high energy - naturally-sweetened drink (NS) - 0.4 kcal/g

Exact details of the preload drink recipes are given in Appendix 6.1. The two sweet drink preloads were piloted prior to investigation to ensure equal palatability and sweetness. Palatability and sweetness have previously been found to influence appetite (e.g. Yeomans, 1996; Rogers and Schutz, 1992; see Chapter 2). Each preload was also sampled and rated by each participant for equality in palatability (all drinks) and sweetness (sweet drinks), immediately prior to consumption of that preload. Ratings were completed immediately prior to consumption of each preload, due to the possible effects of the exercise session on taste perception (see Westerterp-Plantenga, Verwegen, Ijedema, Wijckmans and Saris, 1997; Saris, Eck, Schroeder, Cramwinckel, van Merzijk, Beckers and Brouns, 1991). All preloads were given in unlimited quantities to allow for individual differences in fluid loss during the exercise session. Preload consumption was measured by weight consumed. Any differences between preloads in weight consumed were taken into consideration in the analysis. Weight consumed can be very influential in appetite (Rolls, Castellanos, Halford, Kilara, Panyam, Pelkman, Smith and Thorwart, 1998; de Graaf and Hulshof, 1996).

All participants experienced all three preloads, each on a separate study day, approximately one week apart. The order of presentation of the preloads was counter-balanced across all participants.

6.2.4 MEASURES OF SUBSEQUENT APPETITE

Subsequent appetite was measured using subjective and behavioural measures.

6.2.4.1. Subjective Measures

Subjective perceptions of appetite were measured using 150mm V.A.S. of Hunger, Desire to Eat, Fullness, Prospective Consumption and Thirst. Subjective appetite was measured throughout the day, as detailed in section 6.2.6. 150mm V.A.S. were used to aid the completion of measurements whilst simultaneously exercising.

Subjective perceptions of preload palatability were measured using 100mm V.A.S. of Palatability and Sweetness. These perceptions were measured immediately after sampling 25ml of each preload prior to unlimited consumption of that preload.

6.2.4.2. Behavioural Measures

Behavioural expressions of appetite were measured using: extent of consumption in an ad-libitum test meal (test meal intake), total energy intake and time delay before consumption.

Test Meal Intake was measured as weight of food consumed (gram.), energy content of food consumed (kcal.) and proportions of all macronutrients consumed (% kcal.). The test meal was composed of: tuna mayonnaise and lettuce sandwiches, coleslaw, cheese and tomato pizza, breadsticks, confectionery, strawberry yoghurt and water. All foods were served in excess. Recipes and the energy and macronutrient content of all foods can be found in Appendix 6.2.

Total Energy Intake (kcal.) was calculated as energy intake from the test meal plus energy intake from the preload drinks.

Time Delay before consumption was measured as the time interval (min.) each participant allowed between the availability of the food and the start of consumption.

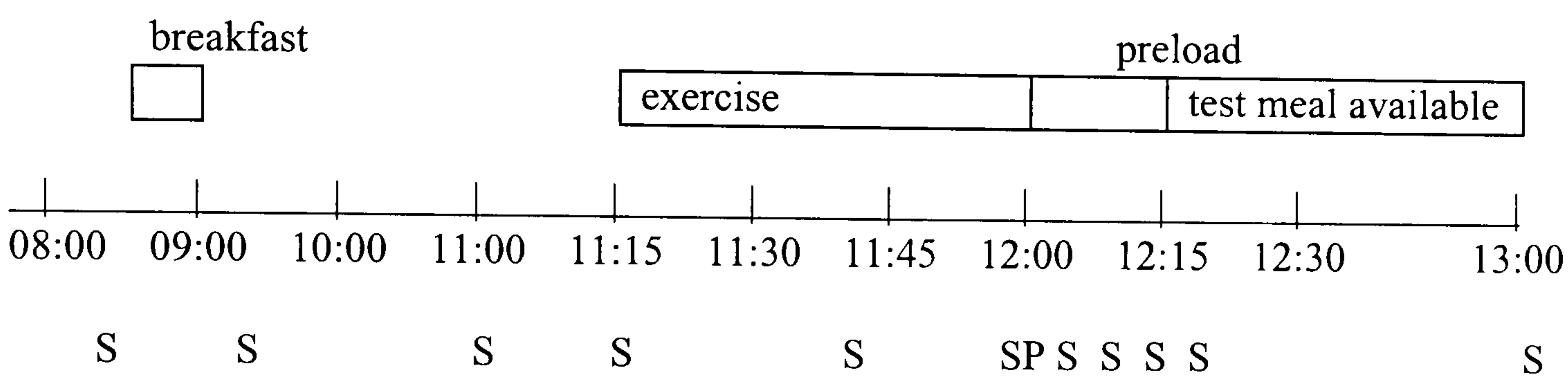
6.2.5. EXERCISE SESSION

A high intensity, long duration exercise session was included in each study day prior to the consumption of the preload. All sessions involved running on a treadmill. The session differed in intensity and duration for each participant, depending on fitness levels. Exercise intensity was set at 70% VO_2max (running speed - 6mph, approx. gradient - 1.5^o). Exercise duration was set at $2*(4.1*\text{body weight})/(3.43*VO_2max)$ (see Thompson, Wolfe and Eikelboom, 1988) (approx. duration - 45 min.). Each exercise session for each participant was identical on all three study days.

6.2.6. PROCEDURE

A time line of each study day is shown in Figure 6.1. On each study day all participants were required to be in the Human Nutrition Unit from 08:30 to 09:00 and from 11:00 to 13:00. At all other times, participants were free to behave as normal, but were instructed to refrain from eating or drinking anything except water and to refrain from any hard physical activity. A standardised breakfast was consumed on all study days. All three study days were identical, excepting the preload drink received.

Figure 6.1: Time Line of Each Study Day in Study 1.



S = Completion of Subjective Measures of Appetite
P = Completion of Subjective Measures of Preload Palatability

6.2.7. ANALYSIS

Methodological Characteristics: Methodological characteristics were analysed prior to all data analyses by 1-way repeated measures ANOVA and Pearson Product Moment Correlations. If differences were found between preload conditions, or if significant relationships were found between any of the methodological characteristics and Test Meal Intake (kcal.), those methodological characteristics were included in all analyses of appetite as covariates.

Subjective Measures of Appetite: All Subjective Measures are described as temporal profiles and were analysed using 2-way repeated measures ANCOVA (preload by time, covariate - weight of preload consumed). Student-Newman-Keuls t-tests were used to investigate significant ANCOVA results.

Behavioural Measures of Appetite: Test Meal Intake (weight, energy, macronutrient proportions), Total Energy Intake and Time Delay before consumption were analysed using 1-way repeated measures ANCOVA (preload, covariate - weight of preload consumed). Student-Newman-Keuls t-tests were used to investigate significant ANCOVA results.

6.2.8. ADDITIONAL MEASURES

Various additional measurements were also taken in the study. These measures investigated the effects of exercise on appetite and will not be considered further in this thesis.

6.3. RESULTS

6.3.1. METHODOLOGICAL CHARACTERISTICS

6.3.1.1. Exercise Session

The three exercise sessions completed by each participant were designed to be equal in intensity, duration and energy expenditure. No significant differences were found between exercise sessions in exercise intensity ($F(2,30)=0.98$, $p=0.39$), or energy expended ($F(2,30)=0.65$, $p=0.53$). No relationships were found between exercise intensity or energy expended and subsequent consumption (exercise intensity: $r=0.090$, $p=0.54$; energy expended: $r=-0.184$, $p=0.14$). Duration of all exercise sessions were identical.

6.3.1.2. Preload Palatability

All preloads were designed to be equally palatable. No significant differences were found in subjective perceptions of palatability ($F(2,30)=2.83$, $p=0.08$). The two sweet drink preloads were also designed to be equal in sweetness. No significant differences were found in subjective perceptions of sweetness ($t(15)=-0.99$, $p=0.34$). No relationships were found between preload palatability or sweetness and subsequent consumption (palatability: $r=0.116$, $p=0.43$; sweetness: $r=-0.137$, $p=0.35$).

6.3.1.3. Preload Consumption

The amount of each preload consumed on each study day was also designed to be equal. Significant differences however were found between preloads ($F(2,30)=5.37$, $p=0.01$). Participants drank significantly more of the AS preload than W ($t(15)=-3.19$, $p=0.01$). No differences were found between AS and NS ($t(15)=1.17$, $p=0.26$), or between NS and W ($t(15)=-1.88$, $p=0.08$). No relationship was found between weight of drink consumed and test meal intake ($r=0.073$, $p=0.62$). Preload consumption (gram.) is shown in Table 6.2.

Due to the differences found between groups and the potential influence on appetite of weight however, weight of preload consumed was used as a covariate in all analyses. The significance of the covariate in all analyses, is shown in Appendices 6.3-6.4.

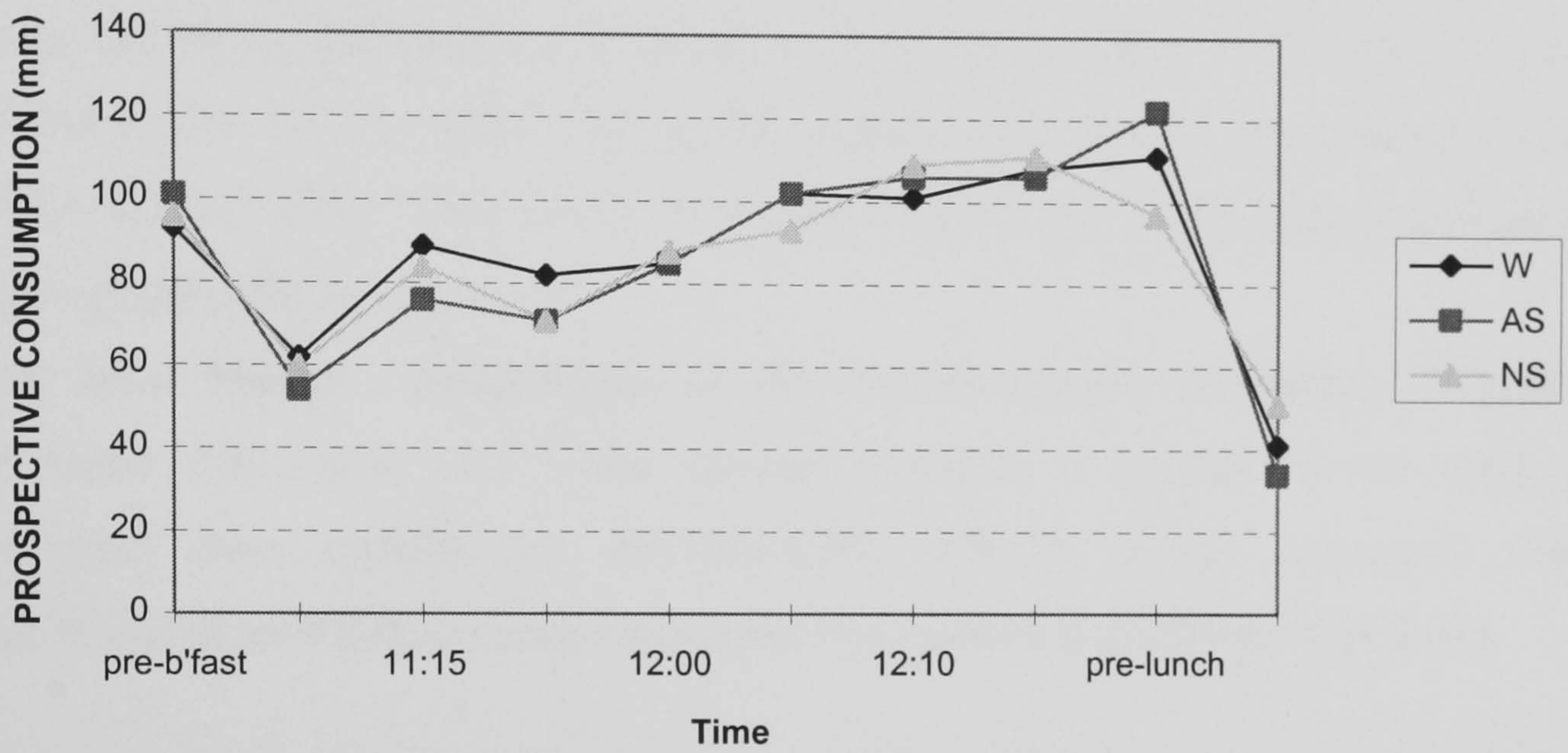
Table 6.2: Preload Consumption (mean (st.dev.)).

	W	AS	NS
Weight (gram)	454.8 (224.4)	617.8 (177.1)	575.7 (187.6)

6.3.2. SUBJECTIVE MEASURES OF APPETITE

In the subjective measures of appetite, no significant differences were found between preloads in any scale (largest $F(2,29)=1.05$, $p=0.36$). Significant effects of time were found in all scales (smallest $F(9,135)=12.68$, $p<0.001$). A significant preload by time interaction was found in the scale of Prospective Consumption ($F(18,270)=2.11$, $p=0.006$). Participants reported themselves able to consume significantly more immediately after consumption of the AS preload than after NS (t(15)=2.96, p=0.01). No differences were found between AS and W (t(15)=1.90, p=0.07) or W and NS (t(15)=-1.29, p=0.22). No differences were found between preloads following lunch (largest t(15)=-2.05, p=0.06). No other interactions were found (largest F(18,270)=1.32, p=0.17). The temporal profile for subjective measures of Prospective Consumption is shown in Figure 6.2.

Figure 6.2: Temporal Profile for Subjective Measures of Prospective Consumption.



6.3.3. BEHAVIOURAL MEASURES OF APPETITE

6.3.3.1. Extent of Consumption

Weight Consumed (gram.), Energy Consumed (kcal.), Total Energy Intake (kcal.), and Proportions of Energy Consumed from All Macronutrients (%kcal.) are shown in Table 6.3.

Table 6.3: Extent of Consumption following Each Preload (mean (st.dev.))

	W	AS	NS
Weight Consumed (gram.)	753.2 (158.9)	824.2 (203.3)	728.7 (160.0)
Energy Consumed (kcal.)	1359.2 (389.8)	1521.4 (457.3)	1332.3 (383.5)
Total Energy Intake (kcal.)	1359.2 (389.8)	1533.0 (457.3)	1564.2 (383.5)
Energy consumed - CHO (%kcal.)	62.1 (9.3)	63.2 (8.1)	61.9 (9.9)
Energy consumed - Fat (%kcal.)	17.2 (4.4)	15.9 (4.4)	17.3 (5.1)
Energy consumed - Protein (%kcal.)	15.9 (1.7)	15.2 (1.9)	15.5 (2.8)

Test Meal Intake - Weight Consumed (gram.): In test meal intake measured as weight consumed, significant differences were found between preloads (F(2,29)=4.43, p=0.02). Participants consumed significantly more weight of food following AS than following W (t(15)=-2.58, p=0.02), and NS (t(15)=2.32, p=0.04). No significant differences were found following W and NS (t(15)=0.87, p=0.40).

Test Meal Intake - Energy Consumed (kcal.): Significant differences were also found between preloads, in test meal intake measured as energy consumed (F(2,29)=4.56, p=0.02). Participants consumed significantly more energy following AS than following W (t(15)=-2.61, p=0.02), and NS (t(15)=2.30, p=0.04). No significant differences were found between W and NS (t(15)=0.49, p=0.63). Energy Consumed (kcal.) following each preload is shown graphically in Figure 6.3.

Total Energy Intake (kcal.): In total energy intake, significant differences were found between preloads (F(2,29)=4.13, p=0.03). Participants consumed significantly less total energy following and including W than following and including AS (t(15)=-2.78, p=0.01) and NS (t(15)=-3.53, p=0.003). No significant differences were found between AS and NS (t(15)=-0.39, p=0.70). Total Energy Intake (kcal.) following and including each preload is shown graphically in Figure 6.4.

Test Meal Intake - Proportions of all Macronutrients Consumed (%kcal.): No significant differences were found between preloads in amount of test meal energy consumed from carbohydrate (F(2,29)=0.99, p=0.39), energy consumed from fat (F(2,29)=2.95, p=0.07), or energy consumed from protein (F(2,29)=0.18, p=0.84).

Figure 6.3: Energy Consumed (kcal.) following Each Preload

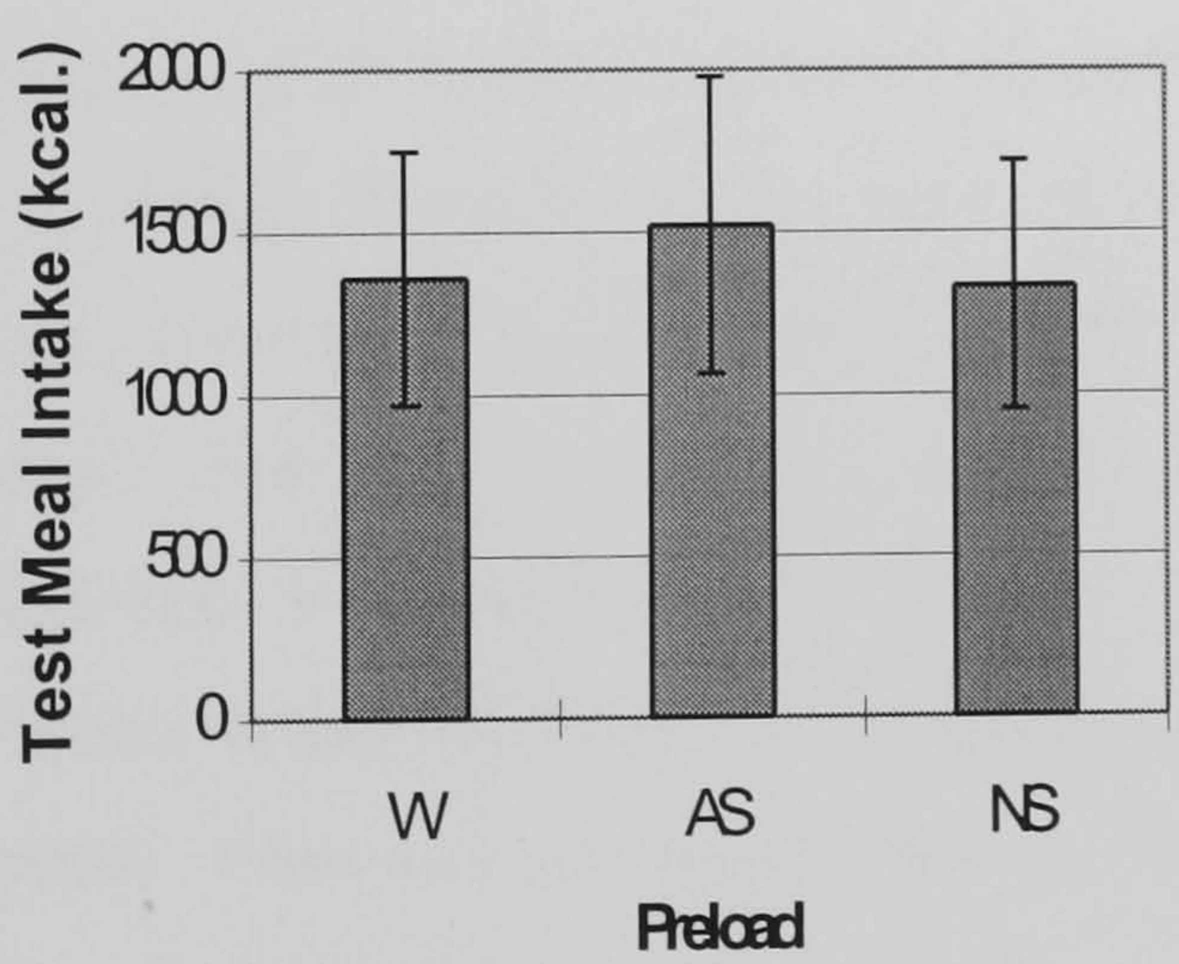
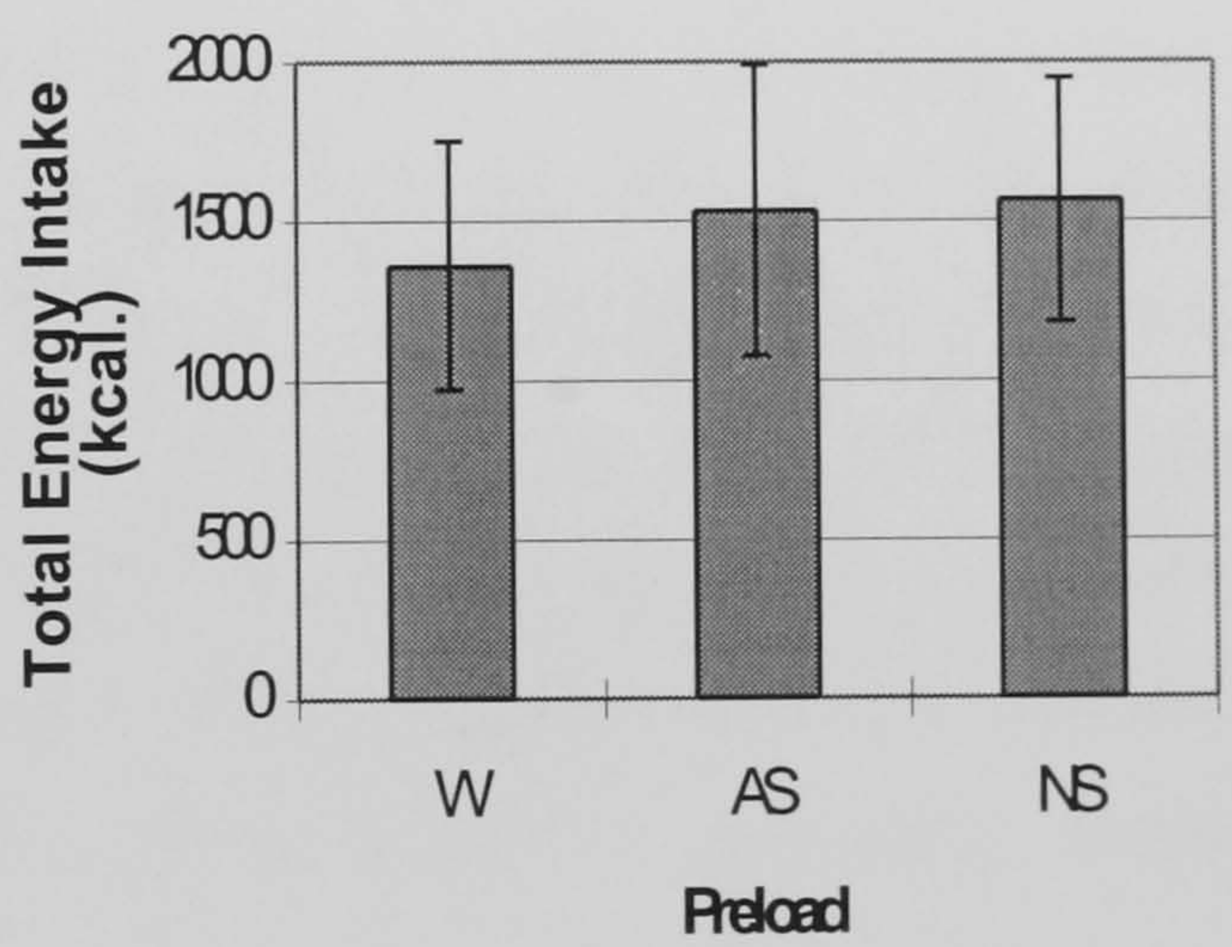


Figure 6.4: Total Energy Intake (kcal.) following and including each Preload



6.3.3.2. Time Delay Before Consumption

In time delay before consumption (min.), no significant differences were found between preloads (F(2,29)=0.01, p=0.96). Time delay before consumption (min.) following each preload is shown in Table 6.4.

Table 6.4: Time Delay before Consumption following Each Preload (mean (st.dev.)).

	W	AS	NS
Time Delay (min.)	9.9 (7.8)	10.1 (8.9)	10.3 (7.7)

6.4. DISCUSSION

6.4.1. THE EFFECTS ON APPETITE OF SWEETNESS (W vs. AS) AND ENERGY (AS vs. NS)

The main findings of this study are:

- Participants consumed significantly more in test meal intake (weight of food, energy) following an artificially sweetened drink preload (AS) compared to a water preload (W).
- Participants consumed significantly less in test meal intake (weight of food, energy) following a naturally-sweetened drink preload (NS) compared to an artificially-sweetened drink preload (AS).

These findings clearly demonstrate the effects on appetite of the single consumption of sweetness without energy. Comparing two equi-energetic preloads, the addition of sweetness to one increases subsequent appetite. Comparing two equi-sweet preloads, the substitution of energy in one decreases subsequent appetite. Sweetness without energy can stimulate appetite. These findings also clearly support a number of previous studies showing similar increases in appetite in response to sweetness without energy (e.g. Reid and Hammersley, 1995; Guss, Kissileff and Pi-Sunyer, 1994, Black, Leiter and Anderson, 1993).

This stimulation of appetite can be understood, as discussed in Chapter 2, with reference to the reliable association between sweetness and energy (Blundell, Rogers and Hill, 1988b). By association, sweetness as a taste can cue the subsequent physiological effects of energy. Consequently, sweet taste results in the anticipation of subsequent energy. Sweetness consumed without energy results in this anticipation remaining unfulfilled. Mediated biochemically, this unfulfilled anticipation will result in a persistence of blood hyperinsulinaemia and hypoglycaemia. Hypoglycaemia results in increases in appetite. Mediated by associative conditioning, this unfulfilled anticipation results in increases in appetite.

The association between sweetness and energy (mediated biochemically or by associative conditioning) is the most plausible explanation for the stimulation of appetite found. An appropriate and sensitive methodology for investigating the effects on appetite of sweetness uncoupled from energy was used. The stimulation of appetite found is also unlikely to result from the three compromises in the methodology. Effects are not due to the quantity of preload consumed. The increased appetite found is also unlikely to have resulted from the use of aspartame. Aspartame has previously only been suggested to either reduce appetite (e.g. Rogers, Burley, Alizhanizadeh and Blundell, 1995; Rogers, Keedwell and Blundell, 1991) or to have no effects (e.g. Anderson, Saravis, Schacher, Zlotkin and Leiter, 1989; Ryan-Harshman, Leiter and Anderson, 1987).

The possibility of effects due to the additional flavour in the sweet preloads is less easy to negate. Flavours can influence appetite via physiological, psychological and cultural variables (Hess, 1997). By the use of familiar, palatable and liked flavours in this study, appetite is unlikely to have been influenced by cultural and some physiological variables. Psychologically (and in relation to physiology), flavours can influence appetite either when related to palatability (Yeomans, 1996) or when related to past experience (Duffy, 1996; Birch, McPhee, Steinberg and Sullivan, 1990). All preloads were rated as equally palatable following the exercise session. The increased appetite found following the sweet flavoured drink is unlikely to have resulted from differences in flavour related to palatability. Effects of flavours as related to past experience requires very specific learning from very specific stimuli. Associations between flavours and unnatural contingent experiences are unlikely to systematically influence a large number of participants (see Duffy, 1996). Associations with natural contingent experiences will result in a flavour-energy association (e.g. Birch, McPhee, Steinberg and Sullivan, 1990), in a similar manner as the proposed sweetness-energy association. A sweet flavour-energy association will thus be a specific demonstration of a sweetness-energy association. The possibility of more specific flavour-consequence associations are yet to be investigated. The flavour of the preloads, thus, may have affected appetite, but only via the sweetness-energy association, as a result of the natural association between the flavour and sweetness. Such an effect is likely to be very small. The likelihood of such an effect however is unknown. A flavoured sweetened drink preload was used to allow equivalent levels of palatability and familiarity between all drink preloads. The effects on appetite of palatability (Yeomans, 1996; Rogers and Schutz, 1992) and familiarity (Pliner, Pelchat and Grabski, 1993; Birch and Marlin, 1982) have been previously reported and may be strong.

In conclusion, sweetness without energy can stimulate appetite, and this stimulation in appetite can most plausibly be explained by the reliable association between sweetness and energy.

6.4.2. ADDITIONAL FINDINGS

This study has also produced a number of additional findings. Most interestingly, no difference was found in total energy intake when comparing total energy intake following and including the two equi-sweet drinks (AS and NS). The compensation in test meal intake for the energy consumed in the preload drink was very close to complete. Compensation is frequently reported (e.g. Birch, McPhee and Sullivan, 1989; Rogers and Blundell, 1989b; Foltin, Fischman, Emurian and Rachlinski, 1988), but the degree of compensation found in this study is rarely reported. This effect may be a demonstration of an increased sensitivity to nutritional manipulations following exercise and/or in regular exercisers (see Verger, Lanteaume and Louis-Sylvestre, 1994; Verger, Lanteaume and Louis-Sylvestre, 1992).

Secondly, despite the large effects in test meal intake, no significant effects were found in the time delay between the availability of the meal and the start of consumption, or in the subjective measures of appetite. The absence of effects in both measures may be a result of the included exercise session. Following a high intensity, long duration exercise session, appetite is frequently temporarily suppressed for a time span of 15-20 min (King and Blundell, 1995; King, Burley and Blundell, 1994; Thompson, Wolfe and Eikelboom, 1988). The time delay before eating found in this study can be considered as a demonstration of this suppression in appetite, followed by an extreme and urgent increase in appetite as a result of the exercise session. The similarity in time delay between preloads may simply be a demonstration of the extent of these effects on appetite and the relatively small effect on appetite of the preload manipulation. The effects of the preload on measures of subjective appetite may also be small compared to the effects of the exercise session. Differences between subjective perceptions of appetite may have been present but remained undetected, both by the subjective measures used and by the participants themselves. The absence of effects between preloads in proportions of macronutrients consumed can be attributed to the test meal used - all foods were high in carbohydrate and low in fat.

6.5. SUMMARY

In summary, this study clearly demonstrates the effects on appetite of a single consumption of sweetness without energy. A single consumption of sweetness without energy can stimulate appetite, but effects may be small and difficult to detect relative to other potential influences on appetite.

Chapter 7.

STUDY 2:

THE DEFINITION OF HABITUAL HIGH CONSUMERS OF SWEETNESS WITHOUT ENERGY

7.1. INTRODUCTION

The main objective of this thesis is to investigate uncoupling sweetness and energy in habitual high consumers of artificial sweeteners, or more accurately in habitual high consumers of sweetness without energy. The habitual high consumption of sweetness without energy in the natural world however, can only be achieved by the habitual high consumption of artificially-sweetened beverages and/or artificially-sweetened gum.

Throughout this thesis, the habitual high consumption of sweetness without energy will be investigated in habitual high consumers of artificially-sweetened beverages and/or artificially-sweetened gum. Habitual consumers will be habitual high consumers, due to the concurrent high consumption levels of sweetness with energy. (For simplicity, individual differences in the strength of the initial relationship, the relative experience of sweetness with and without energy, and the duration of experience of sweetness with and without energy will not be considered in defining habitual consumers (see Chapter 3, section 3.1.2). These variables are considered constant across all individuals throughout this thesis. These issues however will be readdressed in Chapter 13, section 13.2.2.1)

Throughout this thesis, habitual high consumers of sweetness without energy will be compared to habitual low consumers. Habitual high and low consumers will be as separate and distinct as possible, in terms of consumption levels of sweetness without energy. To allow more meaningful implication and application, habitual high and low consumers of artificially-sweetened beverages or artificially-sweetened gum will also be as separate and distinct as possible in terms of consumption levels of artificial sweeteners and other artificially-sweetened products.

Habitual high and habitual low consumers will be defined in terms of consumption levels of artificially-sweetened beverages and/or artificially-sweetened gum within the general population. Levels of consumption of all artificially-sweetened products within the general population in the U.K. however, are currently unknown. The most recent surveys conducted in the U.K. were carried out in 1987 (MAFF, 1990) and in 1988 (Hinson and Nicol, 1992). At that time:

> *'the [U.K.] market [for sweeteners and sweetened foods had] not yet stabilised, [and was] continuing to expand and develop' (MAFF, 1990, p.11)*

Current levels of consumption of artificially-sweetened beverages and artificially-sweetened gum may be very different from those reported in these surveys.

7.1.1. AIMS

This study aims to establish consumption levels of sweetness without energy within the general population, and to define the habitual high and low consumers of sweetness without energy in terms of these population levels. Habitual high and low consumers will be defined in terms of habitual consumption levels of artificially-sweetened beverages or habitual consumption levels of artificially-sweetened gum. The settlement between artificially-sweetened beverages and artificially-sweetened gum will depend on the separation of high and low consumers, and the distinctiveness of these two groups in terms of levels of consumption of artificial sweeteners, other artificially-sweetened products, and the reasons for consumption.

The definitions of the habitual high and habitual low consumer of sweetness without energy will be used to define all participants in all subsequent studies in this thesis. To allow meaningful future application, the general population investigated will be restricted to the staff and student population of the University of Leeds.

7.2. METHOD

7.2.1. DESIGN

The study is a questionnaire study investigating levels of consumption of artificially-sweetened beverages and artificially-sweetened gum within the university population. Levels of consumption of artificial sweeteners and other artificially-sweetened products, the reasons for consumption, and demographics, will also be investigated.

7.2.2. QUESTIONNAIRE DESIGN

The questionnaire was a self-report questionnaire investigating 'Sweetness in Food and Drink'. Sugar and artificial sweeteners were included almost equally in the questionnaire, to avoid obvious demand characteristics. The questionnaire is displayed in Appendix 7.1. The whole questionnaire was noticeably short and could be completed in 5 min. Piloting was carried out prior to distribution.

7.2.2.1. Levels of Consumption of Artificially-Sweetened Beverages and Artificially-Sweetened Gum

Levels of consumption of artificially-sweetened beverages and artificially-sweetened gum were investigated using an F.F.Q. Each respondent indicated the frequency at which they consumed a specified quantity of each product, using a scale of 5+ per day, 2-4 per day, 1 per day, 2/3 per week, 1 per week, rarely and never (Margetts, Cade and Osmond, 1989). Consumption levels of artificially-sweetened beverages were investigated by questioning consumption levels of glasses (200ml.) of 'diet/reduced-sugar/sugar-free squash' and cans (330ml.) of 'diet carbonated drinks'. Consumption levels of artificially-sweetened gum were investigated by questioning consumption levels of sticks (4g.) of 'sugar-free chewing gum'. These questions were concealed amongst similar questions relating to other artificially-sweetened products.

7.2.2.2. Levels of Consumption of Artificial Sweeteners

Levels of consumption of artificial sweeteners were investigated using an F.F.Q. as above, questioning consumption levels of various popular products containing large quantities of artificial sweeteners. All products had previously been found to contribute to artificial sweetener consumption levels within the general U.K. population (see MAFF, 1990). The products included were: 'diet/reduced-sugar/ sugar-free squash', 'diet carbonated drinks', 'sugar-free chewing gum', 'sugar-free sweets', 'sugar-free/virtually-fat-free yoghurts/ desserts', 'table top sweeteners', 'regular squash' and 'regular carbonated drinks'. These questions were concealed amongst questions on comparable naturally-sweetened items. Levels of the <u>deliberate</u> consumption of artificial sweeteners were also investigated by considering all responses to all products that were obviously sweetened with artificial sweeteners, e.g. 'diet' carbonated drinks, 'virtually-fat-free' yoghurts. Deliberate consumption was also investigated by the question 'Do you ever consume artificial sweeteners / 'diet' products in preference to sugar / regular products?' (Q3).

7.2.2.3. Reasons for the Consumption of Artificial Sweeteners

Reasons for the consumption of artificial sweeteners were investigated in two questions: 'Why do you think people consume artificial sweeteners? Please rate the importance of taste, health, to reduce sugar intake, to reduce calorie intake, and to aid weight loss as reasons for consumption.' (Q5); and 'Are you currently dieting?' (Q6). These reasons have previously been highlighted as important in explaining the consumption of artificial sweeteners and artificially-sweetened products (Alexander and Tepper, 1995; Nabors and Lemieux, 1993; Hinson and Nicol, 1992)

7.2.2.4. Demographics

The demographics investigated were gender, age, (height, weight,) and calculated B.M.I.

7.2.3. QUESTIONNAIRE DISTRIBUTION

The questionnaire was distributed to 600 university staff and students attending first year lectures in a variety of disciplines. A total of 526 questionnaires (87.7%) were returned completed and could be used.

7.2.4. ANALYSIS

7.2.4.1. Levels of Consumption of Artificially-Sweetened Beverages and Artificially-Sweetened Gum

Levels of consumption of artificially-sweetened beverages and artificially-sweetened gum were analysed by converting each F.F.Q. response into a frequency rating of consumption levels of each of these products per day. A response of 5+ per day = 5, 2-4 per day = 3, 1 per day = 1, 2/3 per week = 2.5/7 or 0.36, 1 per week = 1/7 or 0.14, rarely = 0.001 and never = 0 (Margetts, Cade and Osmond, 1989). Quantity consumed per day was calculated as a product of the frequency rating and the quantity specified on the questionnaire. Quantities specified on the questionnaire and used for analysis were 200ml per glass of artificially-sweetened beverages, 330ml per can of artificially-sweetened beverage and 4g per stick of artificially-sweetened gum. Levels of consumption of artificially-sweetened beverages were calculated by combining consumption levels of 'diet/reduced-sugar/sugar-free squash' and 'diet carbonated drinks'.

Levels of consumption of artificially-sweetened beverages and artificially-sweetened gum were described graphically for the whole population studied. Habitual high consumers and habitual low consumers were defined in terms of these population levels using values corresponding to the highest and lowest 10th percentile.

7.2.4.2. Levels of Consumption of Artificial Sweeteners and Other Artificially-Sweetened Products, Reasons for Consumption and Demographics

Levels of consumption of artificial sweeteners were calculated from the F.F.Q. responses to all questions referring to products containing artificial sweeteners. For each product type, levels of consumption of artificial sweeteners were calculated as a product of the frequency rating of consumption levels of that product per day (calculated as above) and the mean artificial sweetener concentration (mg) of that product type. Mean artificial sweetener concentration (mg) per product type was calculated from artificial sweetener concentration levels in a variety of products per type, manufactured by a variety of companies. Concentrations of individual artificial sweeteners, and the differing potencies of differing individual artificial sweeteners were not considered due to the purpose of the research. All products included in the calculations are displayed in Appendix 7.2. (Actual artificial sweetener concentrations are not displayed as these remain confidential). Calculated mean artificial sweetener concentration (mg) per product type is shown in Table 7.1. Total levels of consumption of artificial sweeteners - non-deliberate were calculated as the sum of consumption levels of artificial sweeteners for all product types. Levels of consumption of artificial sweeteners - deliberate were calculated as the sum of consumption levels of artificial sweeteners for all product types that were obviously sweetened with artificial sweeteners.

High and low consumers of artificially-sweetened beverages and artificially-sweetened gum were compared on levels of consumption of artificial sweeteners and artificially-sweetened products - deliberate and non-deliberate, reasons for the consumption of artificial sweeteners and demographics, using non-parametric Mann-Whitney tests and Chi-square tests. Non-parametric tests were used because all assumptions for parametric tests could not always be met.

All missing data were recognised by the computer as missing, none were replaced.

Table 7.1: Mean Artificial Sweetener Concentration (mg) per Product Type

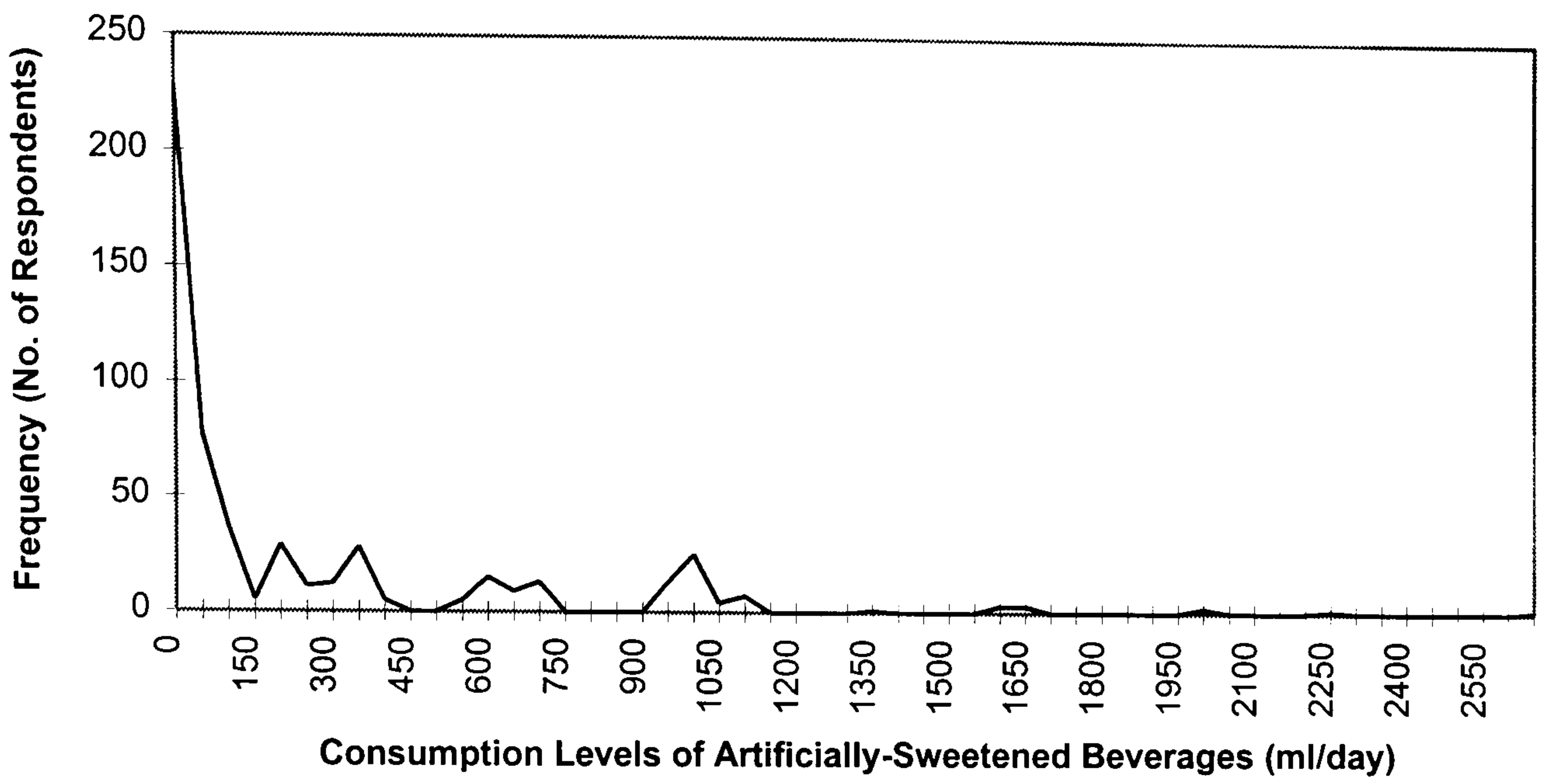
Product Type	Mean artificial sweetener concentration (mg) per item
'Diet' Squash	45 mg per glass (200ml)
'Diet' Carbonated Drinks	140 mg per can (330ml)
'Sugar-Free' Gum	12 mg per stick (4g)
'Sugar-Free' Sweets	15 mg per packet (50g)
'Sugar-free/Virtually-Fat-Free' Yoghurts/Desserts	60 mg per portion (150g)
Table Top Artificial Sweeteners	15 mg per portion
Regular Squash	28mg per glass (200ml)
Regular Carbonated Drinks	40mg per glass (330ml)

7.3. RESULTS

7.3.1. LEVELS OF CONSUMPTION OF ARTIFICIALLY-SWEETENED BEVERAGES

Levels of consumption of artificially-sweetened beverages within the university population were found to range from 0 ml/day to 2650 ml/day, with a mean consumption of 245 ml/day and a median consumption of 46 ml/day. The distribution of consumption was very positively skewed. The distribution of consumption levels of artificially-sweetened beverages within the population studied can be seen in Figure 7.1. Lowest and highest 10th percentile values fall at 0 ml/day and 825 ml/day.

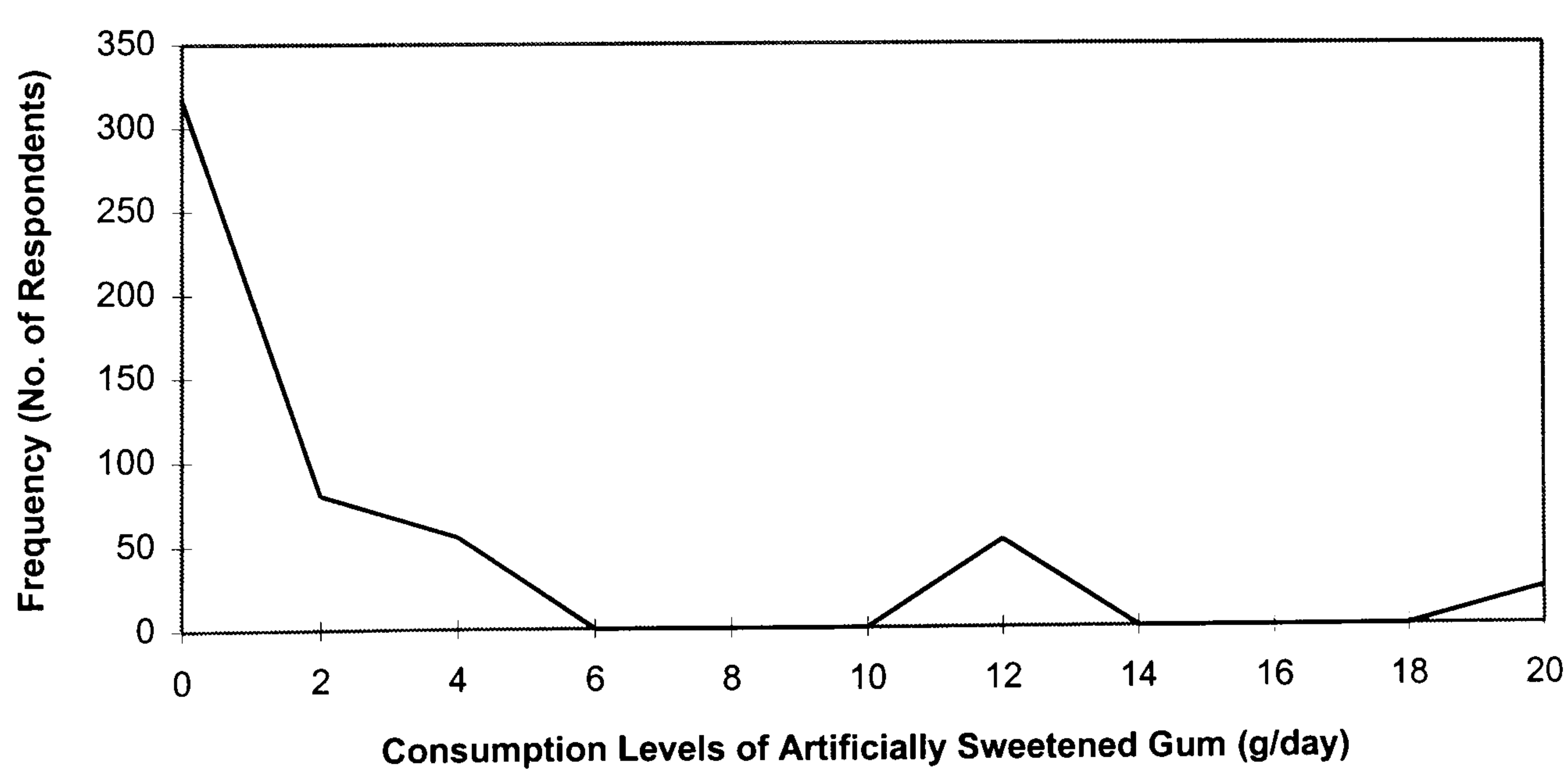
Figure 7.1: The Distribution of Consumption Levels of Artificially-Sweetened Beverages within the University Population



7.3.2. LEVELS OF CONSUMPTION OF ARTIFICIALLY-SWEETENED GUM

Levels of consumption of artificially-sweetened gum within the university population were found to range from 0 g/day to 20 g/day, with a mean consumption of 2.7g/day and a median consumption of 0.6 g/day. The distribution of consumption was very positively skewed. The distribution of consumption levels of artificially-sweetened gum within the population studied can be seen in Figure 7.2. Lowest and highest 10th percentile values fall at 0 g/day and 8 g/day.

Figure 7.2: The Distribution of Consumption Levels of Artificially-Sweetened Gum within the University Population



7.3.3. HIGH AND LOW CONSUMERS OF ARTIFICIALLY-SWEETENED BEVERAGES (HIGH consume ≥ 825 ml/day, LOW consume 0 ml/day)

7.3.3.1. Levels of Consumption of Artificially-Sweetened Products

Significant differences were found between high and low consumers of artificially-sweetened beverages in consumption levels of artificial sweeteners - non-deliberate ($Z=-9.95$, $p<0.001$), consumption levels of artificial sweeteners - deliberate ($Z=-10.04$, $p<0.001$), and in response to Q3 ($\chi^2(1)=57.04$, $p<0.001$). High consumers consumed significantly more artificial sweeteners, and consumed significantly more artificial sweeteners from products that were obviously sweetened with artificial sweeteners, than low consumers. A total of 35.8% high consumers consumed artificially-sweetened/'diet' products in preference to regular products, compared to 8.2% low consumers.

7.3.3.2. Reasons for the Consumption of Artificial Sweeteners

Significant differences were found between high and low consumers of artificially-sweetened beverages in response to Q6 ($\chi^2(1)=6.19$, $p=0.01$). A total of 7.5% high consumers were currently dieting, compared to 2.3% low consumers.

No significant differences were found between high and low consumers of artificially-sweetened beverages in response to Q5:- taste ($\chi^2(1)=2.60$, $p=0.11$), health ($\chi^2(1)=0.49$, $p=0.48$), to reduce sugar intake ($\chi^2(1)=2.48$, $p=0.15$), to reduce caloric intake ($\chi^2(1)=2.16$, $p=0.14$), to aid weight loss ($\chi^2(1)=0.50$, $p=0.48$).

7.3.3.3. Demographics

Significant differences were found between high and low consumers of artificially-sweetened beverages in B.M.I. ($Z=-2.47$, $p=0.01$). High consumers reported themselves of significantly greater B.M.I., than low consumers. No significant differences were found between consumers in gender ($\chi^2(1)=-0.39$, $p=0.53$), or age ($Z=-1.02$, $p=0.31$).

7.3.4. HIGH AND LOW CONSUMERS OF ARTIFICIALLY-SWEETENED GUM (HIGH consume ≥ 8 g/day, LOW consume 0 g/day)

7.3.4.1. Levels of Consumption of Artificially-Sweetened Products

Significant differences were found between high and low consumers of artificially-sweetened gum in consumption levels of artificial sweeteners - non-deliberate ($Z=-7.54$, $p<0.001$), consumption levels of artificial sweeteners - deliberate ($Z=-8.34$, $p<0.001$), and in response to Q3 ($\chi^2(1)=5.13$, $p=0.02$). High consumers consumed significantly more artificial sweeteners, and consumed significantly more artificial sweeteners from products that were obviously sweetened with artificial sweeteners, than low consumers. A total of 12.5% high consumers consumed artificially-sweetened/'diet' products in preference to regular products, compared to 31.4% low consumers.

7.3.4.2. Reasons for the Consumption of Artificial Sweeteners

Significant differences were found between high and low consumers of artificially-sweetened gum in response to Q6 ($\chi^2(1)$=4.09, p=0.04). A total of 3.6% high consumers were dieting, compared to 6.4% low consumers. Significant differences were also found in response to Q5:- to reduce sugar intake ($\chi^2(1)$=4.34, p=0.04). A total of 20.6% high consumers rated the reduction of sugar intake as an important reason for consuming artificial sweeteners, compared to 75.2% low consumers.

No differences were found between high and low consumers of artificially-sweetened gum in answer to Q5:- taste ($\chi^2(1)$=0.05, p=0.83), health ($\chi^2(1)$=1.22, p=0.27), to reduce caloric intake ($\chi^2(1)$=0.58, p=0.45), to aid weight loss ($\chi^2(1)$=0.75, p=0.39).

7.3.4.3. Demographics

Significant differences were found between high and low consumers of artificially-sweetened gum in age (Z=-2.05, p=0.04). High consumers were significantly lower in age, than low consumers. No significant differences were found between consumers in gender ($\chi^2(1)$=2.06, p=0.15) or B.M.I. (Z=2.06, p=0.15).

7.4. DISCUSSION

7.4.1. LEVELS OF CONSUMPTION OF ARTIFICIALLY-SWEETENED BEVERAGES AND ARTIFICIALLY-SWEETENED GUM.

The main findings of this part of the study are:

- Levels of consumption of Artificially-Sweetened Beverages were found to range from 0 ml/day to 2650 ml/day, within the university population. Lowest and highest 10th percentile values fall at 0 ml/day and 825 ml/day.
- Levels of consumption of Artificially-Sweetened Gum were found to range from 0 g/day to 20 g/day, within the university population. Lowest and highest 10th percentile values fall at 0 g/day and 8 g/day.

The levels of consumption of artificially-sweetened beverages reported in this study are higher than those found previously. In the MAFF (1990) survey, consumption levels of artificially-sweetened beverages ranged from 0 ml/day to approximately 650 ml/day (converted from artificial sweetener values using provided conversion factors (MAFF. 1990)). Also, 57% of respondents in the current study were consuming artificially-sweetened beverages, compared to 22%, in the MAFF (1990) survey. Patterns of frequency distribution however are very similar. Levels of consumption of artificially-sweetened beverages have simply increased both in number of consumers and amount consumed per consumer. This increase is likely to be a result of the increased availability and use of artificial sweeteners and artificially-sweetened products, and of the population studied. The levels of consumption found in this study are close to those more recently reported in the U.S.A. (Nabors and Lemieux, 1993). Artificial sweeteners and artificially-sweetened products are more widely available in the U.S.A. and have been used for much longer (Nabors and Lemieux, 1993). The population studied was a university population - i.e. predominantly young adults. Artificially-sweetened beverages are reported to be particularly popular among this age range (Hinson and Nicol, 1992; MAFF, 1990).

Levels of consumption of artificially-sweetened gum appear not to have been surveyed before (see Edgar, 1990).

7.4.2. COMPARISON OF HIGH AND LOW CONSUMERS

The main findings of this part of the study are:

- High consumers of artificially-sweetened beverages consumed significantly more artificial sweeteners and artificially-sweetened products (non-deliberate and deliberate), than low consumers, and more high consumers consumed 'diet' products in preference to regular products and were currently dieting, than low consumers.
- High consumers of artificially-sweetened gum consumed significantly more artificial sweeteners and artificially-sweetened products (non-deliberate and deliberate), than low consumers, but less high consumers consumed 'diet' products in preference to regular products and were currently dieting, than low consumers.

High and low consumers of artificially-sweetened beverages and artificially-sweetened gum have not previously been investigated. In the MAFF (1990) study, however, associations were found between the consumption of artificially-sweetened beverages in preference to regular products and current dieting. The associations found in the current study, where high consumers of artificially-sweetened beverages are also high consumers of artificial sweeteners and other artificially-sweetened products, also consume 'diet' products in preference to regular products and are currently dieting are unsurprising. These results suggest artificially-sweetened beverages to be considered to be one of many artificially-sweetened products, and that these products are used deliberately and are used mainly for reasons of weight control (Alexander and Tepper, 1995). No differences were found between high and low consumers in any of the reasons for consuming artificial sweeteners (Q5), but this is probably due to the impersonal nature of the question asked. Differences may have been found in response to the question 'Why do you consume artificial sweeteners?'.

The associations in the current study in the consumer groups of artificially-sweetened gum are more surprising. High consumers of artificially-sweetened gum consumed more artificial sweeteners and other artificially-sweetened products, compared to low consumers, but more low consumers consumed diet products in preference to regular products and were currently dieting. These results suggest a distinction between artificially-sweetened gum and other artificially-sweetened products, and between consumers of artificially-sweetened gum and consumers of other artificially-sweetened products. These distinctions are also possibly suggested in the significant differences between consumers in the reasons for consumption. High consumers of artificially-sweetened gum are not associating artificial sweetener consumption with a reduction in sugar intake. A distinction between the consumption of artificially-sweetened gum and the consumption of other artificially-sweetened products is also suggested in some of the very limited relevant literature (e.g. Edgar, 1990). Whilst artificially-sweetened beverages appear to be associated with dieting and weight concern, and other artificially-sweetened products, artificially-sweetened gum may be suggested to be more associated with health and dental issues (see Edgar, 1990).

7.5. THE DEFINITION OF HABITUAL HIGH CONSUMERS

In terms of consumption levels within the population studied, habitual high consumers of sweetness without energy can be defined in consumption levels of artificially-sweetened beverages and consumption levels of artificially-sweetened gum. Comparing groups of high and low consumers, high and low consumers of artificially-sweetened beverages are separate and distinct groups of consumers and are likely to remain as such. High consumers of artificially-sweetened beverages are likely to be consuming artificially-sweetened beverages deliberately and are also likely to be deliberately consuming artificial sweeteners and other artificially-sweetened/'diet' products. High consumers of artificially-sweetened beverages thus may also be considered to be a subset of and representative of high consumers of artificial sweeteners. High and low consumers of artificially-sweetened gum, however, although separate, are far less distinct in terms of artificial sweetener consumption, and may easily become undifferentiated. High consumers of artificially-sweetened gum may only be consuming artificial sweeteners in artificially-sweetened gum, and low consumers may be consuming no artificially-sweetened gum but may be consuming other artificially-sweetened products including artificially-sweetened beverages. The high consumption of artificially-sweetened gum would appear to be very distinct from the high consumption of artificial sweeteners.

Throughout this thesis, the habitual consumption of sweetness without energy will be investigated by the comparison of habitual high consumers and habitual low consumers of artificially-sweetened beverages.

Habitual High Consumers are defined as

Consumers of ≥ 825 ml(artificially-sweetened beverages)/day.

Habitual Low Consumers are defined as

Consumers of 0 ml(artificially-sweetened beverages)/day.

Artificially-sweetened beverages are considered to be 'diet/reduced-sugar/sugar-free squash', 'diet carbonated drinks', and tea or coffee sweetened with artificial sweeteners.
825 ml(artificially-sweetened beverages) is equivalent to approximately 2.5 cans of 'diet carbonated drinks', 4 glasses of 'diet/reduced-sugar/sugar-free squash', or 3.5 cups of tea or coffee sweetened with artificial sweeteners.

7.5.1. Advantages and Limitations of This Definition

The main advantages of the use of habitual high consumers of artificially-sweetened beverages lie in the separateness and distinctiveness of the two groups of consumers. The consumption of artificially-sweetened beverages as opposed to artificially-sweetened gum also allows a close likeness between the consumption of sweetness both with and without energy, and a more consistent experience of sweetness without energy. The consumption of artificially-sweetened beverages is very like the consumption of many other drink items in terms of product (flavour, texture, etc.) and behaviour. Artificially-sweetened gum is different to many foods in terms of product, as is typically of a distinct and diminishing peppermint flavour (in the U.K.), and is very different to all foods in terms of behaviour: chewing gum involves extensive mastication, but is followed by no ingestive or digestive behaviours. The high consumption of artificially-sweetened beverages is also closely linked to the high consumption of artificial sweeteners. Any effects found in response to the habitual high consumption of artificially-sweetened beverages will be more generalizable to the high consumption of all artificial sweeteners and artificially-sweetened products, than those found in response to the habitual high consumption of artificially-sweetened gum. Artificially-sweetened beverages are also high contributors to artificial sweetener consumption within the general population (e.g. Hinson and Nicol, 1992) and may be worthy of further investigation in their own right.

The investigation of sweetness without energy using consumption levels of artificially-sweetened beverages, however does also have some limitations. Artificially-sweetened beverages can be consumed in combination with other products. This will result in the consumption of sweetness with energy as opposed to sweetness without energy. The consumption of artificially-sweetened beverages will also result in the ingestion of artificial sweeteners, possibly in large amounts. Any possible effects of the ingestion of artificial sweeteners will be considered in interpreting all investigation findings. A further limitation of the use of consumers of artificially-sweetened beverages lies in the variation in demographics found between high and low consumers. High consumers, in this study, were of a significantly higher B.M.I. than the low consumers. B.M.I. can seriously influence investigations into appetite (e.g. Prentice, Black, Murgatroyd, Goldberg and Coward, 1989). Differences in B.M.I. between high and low consumer groups will be kept as minimal as possible, throughout this thesis, and where necessary will be considered in all analyses. No differences were found between high and low consumers in gender. Both males and females will be studied equally, using the same definition of high and low consumers, throughout the thesis.

7.6. SUMMARY

In summary, this study has established the levels of consumption of sweetness without energy within a university population, and has defined habitual high and habitual low consumers of sweetness without energy in terms of those population levels. Habitual high consumers are defined as consumers of ≥ 825 ml(artificially-sweetened beverages)/day. Habitual low consumers are defined as consumers of 0 ml(artificially-sweetened beverages)/day. These consumer groups are separate and distinct in terms of artificial sweetener consumption, and are likely to remain as such. Habitual high and habitual low consumers of sweetness without energy will be compared in all subsequent studies in this thesis, defined as above.

Chapter 8.

STUDY 3:

UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE:

RESPONSES TO SWEETNESS AND ENERGY WHEN CONSUMED AS A DRINK

The main objective of this thesis is to investigate the effects of uncoupling sweetness and energy in habitual high consumers of artificial sweeteners: effects on appetite and appetite control. Effects on appetite are investigated in a number of highly controlled laboratory studies. The studies are reported in this and the following two chapters.

ABSTRACT

This study investigates the responses to sweetness and energy in male and female, high and low consumers of artificially-sweetened beverages. Subjective and behavioural appetite were measured following 3 sweetness/energy preload manipulations (non-sweet/low energy, sweet/low energy, sweet/high energy). In subjective measures of appetite, no differences were found between consumers. In behavioural measures, the majority of findings in all participants can be attributed to the female participants. In female participants, low consumers of artificially-sweetened beverages consumed a <u>similar</u> quantity of food following all 3 preloads; low consumers thus, demonstrated no responses to sweetness or energy. High consumers consumed significantly <u>more</u> food following the two sweetened preloads. The results in low consumers suggest the sweetness/energy manipulations to have been ineffective in the study. This lack of effect is attributed to the study procedure. The effects in the high consumers are explained as a response to an increased palatability of sweetened drinks to high consumers of artificially-sweetened beverages. No effects of sweetness, energy or palatability were found in male participants. These findings are attributed to the methodology of the study, and a decreased importance of taste in males compared to females.

8.1. INTRODUCTION

As discussed in Chapter 3, uncoupling sweetness and energy in habitual high consumers of sweetness without energy may result in a number of differing effects on appetite. All possible effects on appetite may be investigated by the measurement of appetite in the laboratory. Many of the possible effects suggested in Chapter 3, may be achieved in response to sweetness both with and without energy. Effects of the habitual uncoupling of sweetness and energy may be demonstrated in response to sweetness both with and without energy. Effects of the consumption of sweetness may be demonstrated in response to sweetness both with and without energy.

These possible effects can be investigated by measuring the appetitive responses to sweetness when consumed both with energy and without energy. Appetite and appetitive responses to sweetness and energy will be investigated in the laboratory by the comparison of habitual high and low consumers of sweetness without energy.

8.1.1. AIMS

This study aims to investigate the appetitive responses to sweetness and energy, in habitual high and habitual low consumers of sweetness without energy. Appetitive responses to sweetness and energy will be investigated using an appropriate methodology, as detailed in Chapter 6. Habitual high and low consumers will be defined as detailed in Chapter 7.

8.2. METHOD

8.2.1. DESIGN

The study uses a 2 x 2 x 3 mixed design, investigating gender (2 levels), consumer type (2 levels), and sweetness/energy manipulation (3 levels). The study was conducted using a preloading procedure, where sweetness/energy manipulation was given as a preload and appetite was subsequently measured using subjective and behavioural measures.

8.2.2. CONSUMERS

Two independent groups of consumers participated in the study - habitual high consumers of artificially-sweetened beverages and habitual low consumers of artificially-sweetened beverages. Habitual high consumers were required to be consuming ≥ 825 ml (artificially-sweetened beverages)/day. Habitual low consumers were required to be consuming 0 ml (artificially-sweetened beverages)/day. Consumption levels of all artificially-sweetened beverages were reported by all participants on a self-report Drinks F.F.Q., completed prior to inclusion in the study. The self-report Drinks F.F.Q. questioned consumption levels of a variety of sweet/non-sweet, low/high energy drinks, and is displayed in Appendix 8.1. Equal numbers of males and females participated in the study.

In total, 16 habitual high consumers (8 male and 8 female) and 16 habitual low consumers (8 male and 8 female) took part in the study. Prior to the start of the study, all participants were measured for calculation of B.M.I. and completed the D.E.B.Q., as a measure of dietary restraint. All consumer groups were matched as closely as possible on B.M.I. and dietary restraint (D.E.B.Q.-R.) scores. All participants were familiar with and liked all foods in the study. None of the participants were informed of the exact hypotheses of the study. Participant characteristics are displayed in Table 8.1.

Table 8.1: Participant Characteristics (mean (standard deviation))

Participants	Artificially-Sweetened Beverage Consumption (ml/day)	B.M.I. (kg/m^2)	D.E.B.Q. - R. score
Low - Male (N=8)	0.0 (0.0)	22.6 (1.0)	17.8 (5.0)
Low - Female (N=8)	0.0 (0.0)	21.8 (1.9)	21.4 (5.3)
High - Male (N=8)	1429.8 (390.9)	26.0 (2.9)	20.5 (6.7)
High - Female (N=8)	1938.0 (1653.4)	24.1 (4.6)	35.4 (5.3)

8.2.3. SWEETNESS / ENERGY MANIPULATIONS

The sweetness/energy manipulations were given as a preload drink. The three manipulations used were:

- non-sweet / low energy - water (W) - 0 kcal/330ml
- sweet / low energy - artificially-sweetened drink (AS) - 5 kcal/330ml
- sweet / high energy - naturally-sweetened drink (NS) - 125 kcal/330ml

Exact details of the preload drink recipes are given in Appendix 6.1. The two sweet drink preloads were piloted prior to the investigation to ensure equal palatability and sweetness. All preloads were given as four 330ml drinks, to be consumed throughout the day. Four drinks of 330ml of each preload allowed a high exposure (frequency and quantity) of each preload. The timing of consumption of each drink was fixed at 3.5hr. and 2hr. prior to the following test meal (see section 8.2.5). The timing of the consumption was specified, to accommodate any potential effects on appetite of the artificial sweeteners in the artificially-sweetened (AS) preload (see Chapter 2, section 2.2.4), and was fixed at the longest possible time delay between preload consumption and subsequent meal consumption, to minimize all potential effects (see Stegink, 1984).

All participants experienced all three preloads, each on a separate study day, approximately one week apart. The order of presentation of the preloads was counter-balanced across all participants.

8.2.4. MEASURES OF SUBSEQUENT APPETITE

Subsequent appetite was measured using subjective and behavioural measures.

8.2.4.1. Subjective Measures

Subjective perceptions of appetite were measured using 100mm V.A.S. of Hunger, Desire to Eat, Fullness, Prospective Consumption, Thirst, and Desire to Drink. Subjective appetite was measured throughout the day, as detailed in section 8.2.5.

8.2.4.2. Behavioural Measures

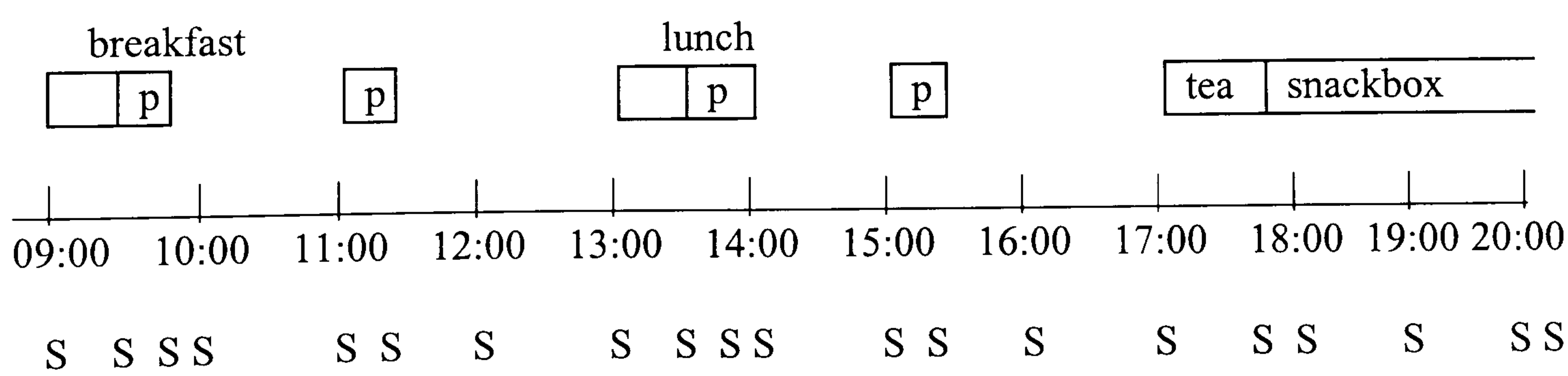
Behavioural expressions of appetite were measured using extent of consumption in four ad-libitum test meals/periods (test meal intake). Test Meal Intake for all test meal/periods was measured as weight of food consumed (gram.), energy consumed (kcal.) and proportions of all macronutrients consumed (%kcal). Test meals/periods were lunch, tea, evening snacks, and the following day. Lunch was composed of: vegetable lasagne, peas, chocolate digestive biscuits, apples and water. Tea was composed of: cream cheese or turkey sandwiches, coleslaw, cheese and tomato pizza, confectionery, strawberry yoghurt and water. The evening snackbox was composed of: bread rolls, margarine portions, cheese portions, jam portions, individual packets of crisps, individual packets of biscuits, apples and yoghurts. All foods were served in excess. Recipes and the energy and macronutrient content of all foods can be found in Appendix 8.2. All drinks consumed in conjunction with the snackbox were recorded by the participants. On the following day, all foods and drinks consumed were recorded by the participants in a 'portion-size' food diary.

Results are provided for each individual test meal - Individual Test Meal Intake (lunch intake, tea intake, evening snack intake, day 2 intake), and for a summation of all test meal intakes throughout the day - Cumulative Test Meal Intake (following lunch, following tea, end of Day 1, end of Day 2). Total Energy Intake (kcal.) was also measured cumulatively as energy intake from test meals plus energy intake from the preload drinks.

8.2.5. PROCEDURE

A time line of each study day is shown in Figure 8.1. On each study day all participants were required to be in the Human Nutrition Unit from 09:00 to 09:45, from 13:00 to 13:45 and from 17:00 to 17:45. At all other times, participants were free to behave as normal, but were instructed to consume the preload drinks in full at the specified times, and to refrain from eating or drinking anything else except water. A standardised breakfast was consumed on all study days. All study days were identical excepting the preload drink received.

Figure 8.1: Time Line of Each Study Day in Study 3.



p = Consumption of Preload Drinks
S = Completion of Subjective Measures of Appetite

8.2.6. ANALYSIS

Participant Characteristics: Prior to analysis of the dependent measures in this study, all consumer groups were compared in artificially-sweetened beverage consumption, B.M.I. and Dietary Restraint Score. Groups of high and low consumers were designed to differ in artificially-sweetened beverage consumption. All groups were designed to be similar in B.M.I. and Restraint. If differences were found between consumer groups, or if a significant relationship was found between B.M.I. and/or Restraint and Total Test Meal Intake on Day 1 (kcal.), B.M.I. and/or Dietary Restraint Score were included in all analyses as covariates. Participant characteristics were analysed by 1-way ANOVA (4 groups) and Pearson Product Moment Correlations.

Subjective Measures of Appetite: All subjective measures of appetite are described as temporal profiles and were analysed using 4-way mixed ANCOVA (gender by consumer by preload by time, covariates - B.M.I., dietary restraint score). Data for male participants were also analysed separately using 3-way mixed ANOVA (consumer by preload by time). Data for female participants were analysed separately using 3-way mixed ANCOVA (consumer by preload by time, covariate - dietary restraint score). Student-Newman-Keuls t-tests were used to investigate all significant ANOVA/ANCOVA results. Due to the constraints of the statistical tests used, subjective ratings were collapsed across some time points, and analyses for multi-way interactions were not always conducted.

Behavioural Measures of Appetite: Individual and Cumulative Test Meal Intake and Total Energy Intake were analysed using 3-way mixed ANCOVA (gender by consumer by preload, covariates - B.M.I. and Dietary Restraint Score). Data for male participants was also analysed using 2-way mixed ANOVA (consumer by preload), and data for female participants was analysed using 2-way mixed ANCOVA (consumer by preload, covariate Dietary Restraint Score). Student-Newman-Keuls t-tests were used to investigate all significant ANOVA/ANCOVA results. Data was missing for one male in evening intake and one male on Day 2, due to excess alcohol intake. Data are also recorded as missing in proportions of all macronutrients consumed if nothing was consumed in a test meal/period.

Due to the amount of data collected, only <u>systematic</u> significant differences are reported below in the text. Significant differences were considered systematic if patterns of similar differences were found in related data (e.g. in lunch <u>and</u> tea intake). <u>All</u> significant differences are reported in the appendices in all results tables.

8.3. RESULTS

8.3.1. PARTICIPANT CHARACTERISTICS

8.3.1.1. Artificially-Sweetened Beverage Consumption

High and low consumers were designed to differ in artificially-sweetened beverage consumption. Significant differences were found between consumer groups ($F(3,28)=10.96$, $p<0.001$). Male high consumers consumed more artificially-sweetened beverages than male and female low consumers ($t(14)=-10.35$, $p<0.001$). Female high consumers consumed more artificially-sweetened beverages than male and female low consumers ($t(14)=-3.32$, $p=0.005$). No differences were found between male and female high consumers ($t(14)=0.85$, $p=0.41$), or between male and female low consumers.

8.3.1.2. B.M.I.

High and low consumers were designed to be similar in B.M.I. Significant differences were found however, between consumer groups ($F(3,28)=3.23$, $p=0.04$). Male high consumers were of a higher B.M.I. than female low consumers ($t(14)=-3.47$, $p=0.005$). No significant differences were found between other groups (largest $t(14)=-2.17$, $p=0.04$ (adjusted significance criteria of 0.05/7)). No relationship was found between B.M.I. and total Test Meal Intake on Day 1 (all participants: $r=0.314$, $p=0.09$; male participants: $r=0.378$, $p=0.18$; female participants: $r=0.132$, $p=0.63$).

Due to the differences found between groups, and the potential influence on appetite of B.M.I., B.M.I. was used as a covariate in all analyses on all participants. The significance of the covariate in all analyses is shown in Appendices 8.12 -8.13. B.M.I. was not used as a covariate in analyses on male and female participants only.

8.3.1.3. Dietary Restraint

High and low consumers were also designed to be similar in Dietary Restraint. Significant differences however, were found between consumer groups ($F(3,28)=15.84$, $p<0.001$). Female high consumers were significantly more restrained than female low consumers, male low and male high consumers (smallest $t(14)=-4.62$, $p<0.001$). No significant differences were found between other groups (largest $t(14)=1.40$, $p=0.18$). A significant relationship was also found between Dietary Restraint and total Test Meal Intake on Day 1 in female participants ($r=0.536$, $p=0.03$). No relationship was found in all participants ($r=0.001$, $p=0.99$) or in male participants ($r=0.1.02$, $p=0.72$).

Due to the differences found between groups, the significant relationship and the potential influence on appetite of dietary restraint, D.E.B.Q.-R. score was used as a covariate in all analyses on all participants and on female participants only. The significance of the covariate in all analyses is shown following all analyses in Appendices 8.12 - 8.13. D.E.B.Q.-R. scores was not used in analyses only on male participants.

B.M.I. and Dietary Restraint scores were not related (all participants: r=0.041, p=0.82; male participants: r=0.159, p=0.56; female participants: r=0.209, p=0.44).

8.3.2. SUBJECTIVE MEASURES OF APPETITE

8.3.2.1. All Participants

In all scales of subjective measures of appetite, no significant differences were found between genders (largest F(1,26)=1.71, p=0.20), consumers (largest F(1,26)=2.79, p=0.11), or preloads (largest F(2,56)=1.49, p=0.23). Significant effects of time were found (smallest F(4,112)=28.47, p<0.001). Significant gender by consumer interactions were found in scales of Thirst and Desire to Drink (smallest F(1,26)=5.67, p=0.03) (see Figure 8.2 and 8.3). In male participants, low and high consumers reported <u>similar</u> levels of thirst (smallest t(14)=0.93, p=0.37)); in female participants, high consumers demonstrated a trend toward higher levels of thirst (smallest t(14)=-1.54, p=0.14). No other interactions were found (largest F(8,224)=1.92, p=0.06). Temporal Profiles for scales of Thirst and Desire to Drink (gender by time) are shown in Appendices 8.3-8.4.

Figure 8.2: Interaction Graph for Subjective Measures of Thirst
All Participants - Gender by Consumer

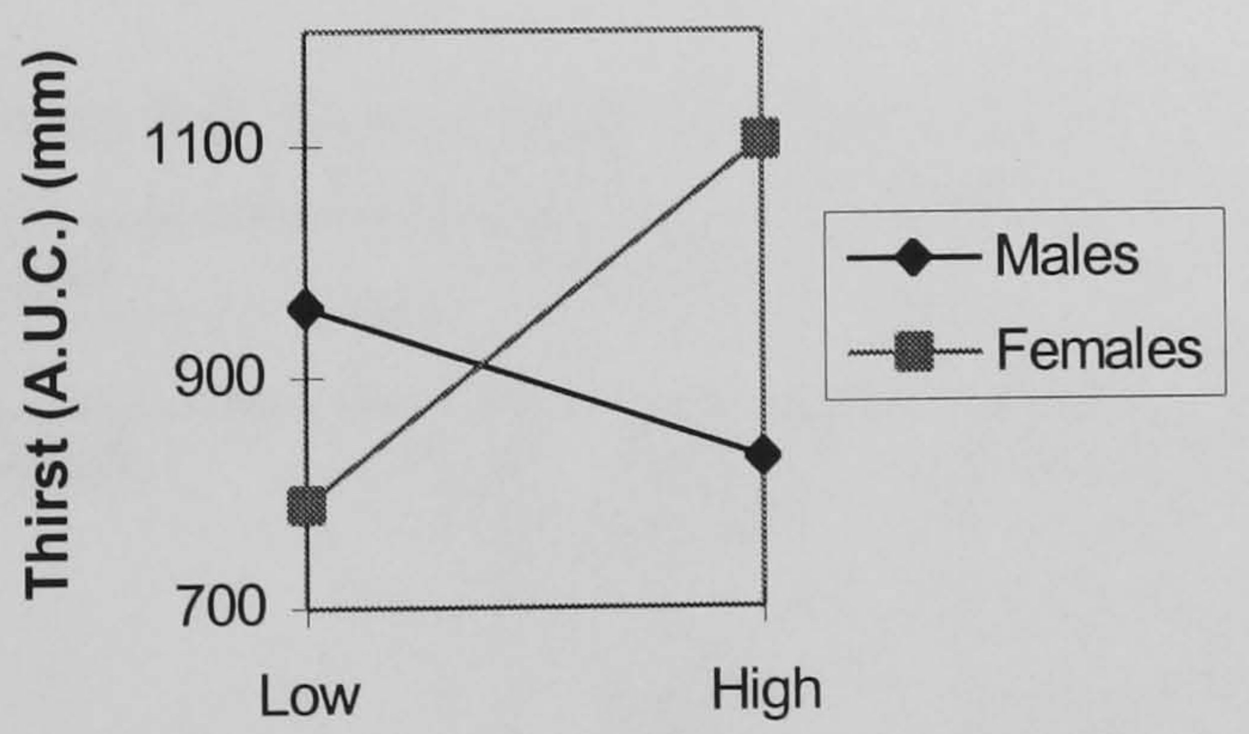
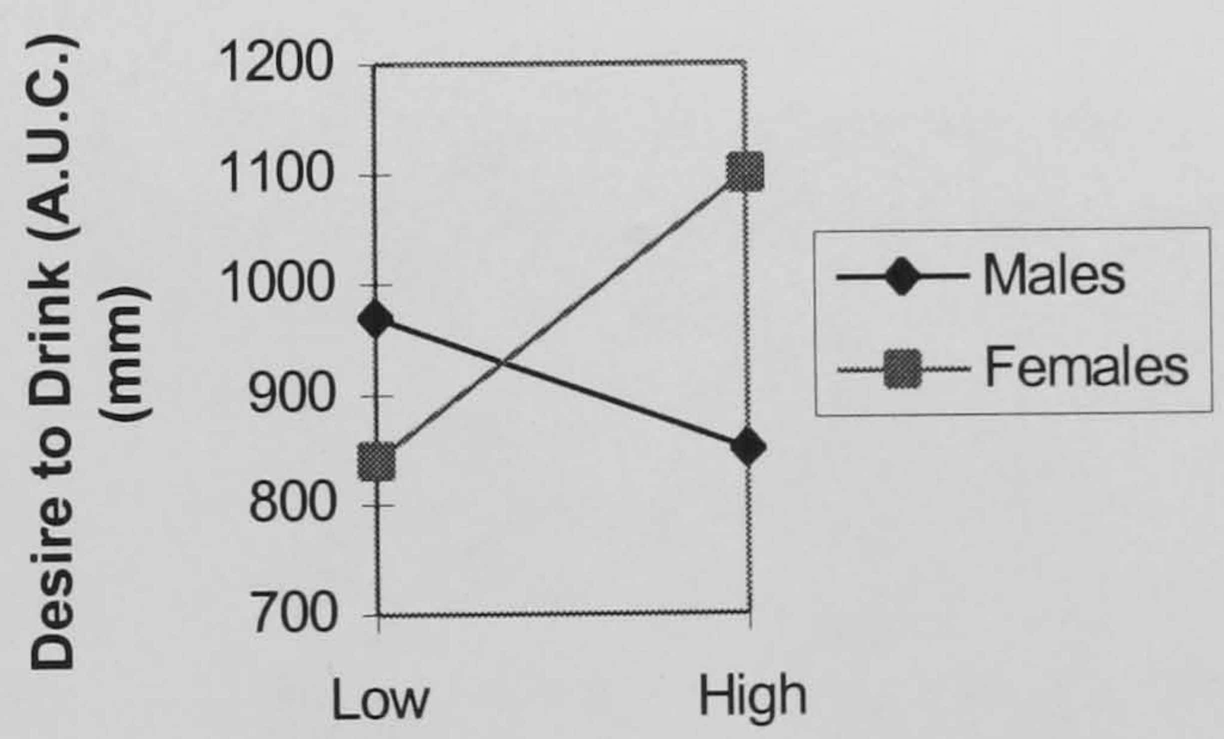


Figure 8.3: Interaction Graph for Subjective Measures of Desire to Drink - All Participants - Gender by Consumer



8.3.2.2. Male Participants

In all scales of subjective measures of appetite, no significant differences were found between consumers (largest F(1,14)=1.23, p=0.29) or preloads (largest F(2,28)=0.57, p=0.57). Significant effects of time were found (smallest F(4,56)=17.05, p<0.001). No significant 2-way interactions were found (largest F(2,28)=1.14, p=0.33). Analyses for multi-way interactions were not conducted.

8.3.2.3. Female Participants

In all scales of subjective measures of appetite, no significant differences were found between consumers (largest $F(1,13)=4.22$, $p=0.06$), or preloads (largest $F(2,28)=2.27$, $p=0.12$). Trends were found between consumers in scales of thirst and desire to drink. High consumers reported higher levels of thirst. Significant effects of time were found (smallest $F(4,56)=12.83$, $p<0.001$). No 2-way interactions were found (largest $F(2,28)=1.72$, $p=0.20$). Analyses for multi-way interactions were not conducted.

8.3.3. BEHAVIOURAL MEASURES OF APPETITE

8.3.3.1. All Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual Test Meal Intake, no systematic significant differences were found between genders, consumers, or preloads. No systematic significant interactions were found. Individual Test Meal Intake - Weight Consumed is shown in Appendix 8.5.

In Cumulative Test Meal Intake, consistent significant differences were found between genders (smallest $F(1,24)=7.58$, $p=0.01$). Males consumed more weight of food than females. No significant differences were found between consumers (largest $F(1,24)=2.75$, $p=0.11$) or preloads (largest $F(2,25)=1.76$, $p=0.18$). No systematic interactions were found. Cumulative Test Meal Intake - Weight Consumed is shown in Table 8.2, and is also shown (with analysis) in Appendix 8.6.

Table 8.2: Cumulative Test Meal Intake - Weight Consumed (gram.) - means (st.dev.)

Meal	Consumer	Sweetness / Energy Manipulation		
		W	AS	NS
Lunch	M - Low	973 (249)	984 (248)	936 (228)
	M - High	844 (197)	968 (260)	880 (250)
	F - Low	730 (132)	626 (83.5)	623 (192)
	F - High	646 (139)	807 (262)	780 (259)
+ Tea	M - Low	1608 (381)	1625 (502)	1577 (361)
	M - High	1372 (299)	1512 (417)	1407 (379)
	F - Low	1102 (130)	994 (137)	996 (190)
	F - High	1087 (271)	1266 (367)	1259 (404)
+ Evening	M - Low	1906 (503)	2009 (545)	1849 (434)
	M - High	1741 (474)	1895 (571)	1768 (540)
	F - Low	1277 (196)	1164 (135)	1142 (156)
	F - High	1362 (454)	1508 (431)	1501 (568)
+ Day 2	M - Low	3263 (793)	3476 (1021)	3348 (715)
	M - High	2738 (466)	2917 (946)	3087 (646)
	F - Low	2370 (398)	2466 (588)	2339 (424)
	F - High	2314 (593)	2509 (583)	2511 (546)

Consumer: M = Male, F = Female; Low = Low Consumer of Artificially-Sweetened Beverages,
High = High Consumer of Artificially-Sweetened Beverages.

Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, significant differences were found between genders in lunch intake (F(1,26)=5.84, p=0.02) and in evening intake (F(1,26)=4.59, p=0.04). Males consumed more energy than females. No significant differences were found between consumers (largest F(1,26)=2.98, p=0.10) or preloads (largest F(2,56)=2.98, p=0.10). A significant interaction (consumer by preload) was found in lunch intake (F(2,56)=3.51, p=0.04) (see Figure 8.4). Low consumers consumed a <u>similar</u> amount of energy following AS and W (t(15)=-0.98, p=0.34); high consumers consumed significantly <u>more</u> energy following AS than following W (t(15)=2.95, p=0.01). No other interactions were found (largest F(2,56)=2.33, p=0.11). Individual Test Meal Intake - Energy Consumed is shown in Appendix 8.7.

In Cumulative Test Meal Intake, consistent significant differences were found between genders (smallest F(1,26)=5.08, p=0.03). Males consumed more energy than females. No significant differences were found between consumers (largest F(1,24)=0.30, p=0.59) or preloads (largest F(2,56)=0.83, p=0.44). Significant (consumer by preload) interactions were found following tea (F(2,56)=3.51, p=0.04) (see Figure 8.5). Low consumers consumed a <u>similar</u> amount of energy following AS and W (t(15)=-1.33, p=0.20); high consumers consumed significantly <u>more</u> energy following AS than W (t(15)=3.08, p=0.01). No other interactions were found (largest F(2,56)=1.28, p=0.29). Cumulative Test Meal Intake is shown in Table 8.3 and (with analysis) in Appendix 8.8.

Figure 8.4: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - All Participants - Lunch Intake - Consumer by Preload

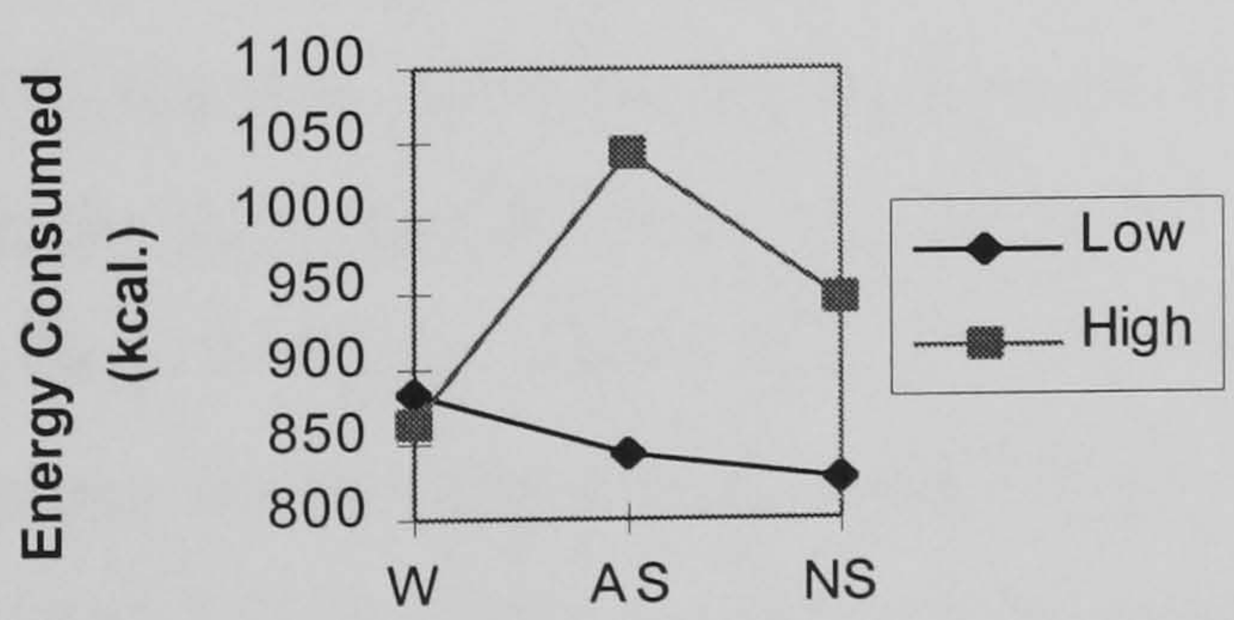


Figure 8.5: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - All Participants - Cumulative Intake following Tea - Consumer by Preload

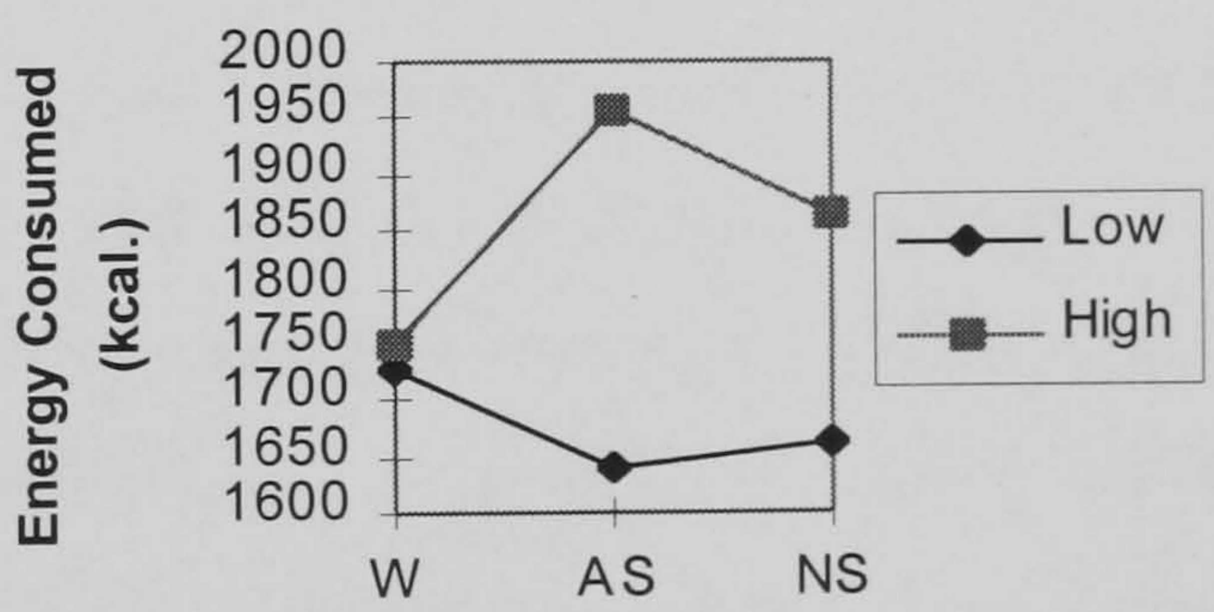


Table 8.3: Cumulative Test Meal Intake - Energy Consumed (kcal.) - means (st.dev.)

Meals	Consumer	Sweetness / Energy Manipulation		
		W	AS	NS
Lunch	M - Low	1028 (304)	1037 (289)	972 (300)
	M - High	1001 (207)	1113 (305)	969 (310)
	F - Low	740 (65)	648 (66)	684 (297)
	F - High	727 (196)	976 (316)	923 (337)
+ Tea	M - Low	2095 (527)	2026 (694)	2029 (527)
	M - High	1964 (558.9)	2107 (750)	1932 (649)
	F - Low	1362 (208)	1249 (317)	1295 (336)
	F - High	1538 (300)	1808 (438)	1797 (505)
+ Evening	M - Low	3093 (752)	2978 (702)	2894 (789)
	M - High	3106 (838)	3243 (829)	2934 (905)
	F - Low	1975 (492)	1924 (336)	1923 (355)
	F - High	2435 (637)	2692 (626)	2615 (1083)
+ Day 2	M - Low	5397 (1205)	5292 (1029)	5504 (833)
	M - High	5387 (679)	5511 (906)	5694 (1811)
	F - Low	3721 (749)	3824 (514)	4044 (748)
	F - High	4368 (945)	4700 (387)	4326 (884)

Consumer: M = Male, F = Female; Low = Low Consumer of Artificially-Sweetened Beverages, High = High Consumer of Artificially-Sweetened Beverages.

Total Energy Intake (kcal.):

In Cumulative Total Energy Intake, effects of gender and consumer remained as in test meal intake - energy consumed. Consistent significant differences were also found between preloads (smallest $F(2,52)=8.44$, $p=0.001$). Participants consumed significantly more total energy on the days they received NS than on the days they received AS (smallest $t(30)=-3.16$, $p=0.004$) or W (smallest $t(30)=-3.69$, $p=0.001$). No significant differences were found between W and AS (largest $t(31)=1.90$, $p=0.07$). Significant interactions were found between consumer and preload following lunch ($F(2,56)=3.51$, $p=0.04$) and following tea ($F(2,56)=3.51$, $p=0.04$). Again, low consumers consumed a similar total amount of energy on the days they received AS and on the days they received W (following lunch: $t(15)=-0.74$, $p=0.47$; tea: $t(15)=-1.04$, $p=0.32$); high consumers consumed significantly more total energy on the days they received AS than on the days they received W (following lunch: $t(15)=-3.11$, $p=0.01$; tea: $t(15)=3.38$, $p=0.004$). No other interactions were found (largest $F(2,56)=1.28$, $p=0.29$). Cumulative Total Energy Intake is shown in Appendix 8.9.

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate and fat, no systematic differences were found between genders. No significant differences were found between consumers (largest $F(1,25)=3.58$, $p=0.07$) or preloads (largest $F(2,54)=3.09$, $p=0.09$). No systematic interactions were found. In proportions of energy consumed from protein, no systematic differences were found between genders. Significant differences were found between consumers in lunch intake (F(1,26)=4.62, p=0.04), in evening intake (F(1,22)=8.39, p=0.01) and on the following day (F(1,24)=3.40, p=0.04). On Day 1, low consumers consumed significantly more energy from protein than high consumers. On the following day, low consumers consumed significantly less energy from protein than high consumers. No significant differences were found between preloads (largest F(2,48)=1.26, p=0.29). No interactions were found (F(2,52)=2.30, p=0.11). Individual Test Meal Intake - Proportions of All Macronutrients Consumed are shown in Appendix 8.10.

In cumulative test meal intake, in proportions of energy consumed from carbohydrate and fat, no significant differences were found between genders (largest F(1,25)=2.09, p=0.16), consumers (largest F(1,25)=3.58, p=0.07), or preloads (F(2,52)=2.58, p=0.09). No systematic interactions were found. In proportions of energy consumed from protein, no systematic differences were found between genders. Consistent significant differences were found between consumers (smallest F(1,26)=4.85, p=0.04). Low consumers consumed significantly more energy from protein than high consumers. No significant differences were found between preloads (largest F(2,52)=0.36, p=0.70). No significant interactions were found (largest F(2,54)=2.30, p=0.11). Cumulative Test Meal Intake - Proportions of All Macronutrients Consumed are shown in Appendix 8.11.

Summary: All systematic significant results for all participants in the behavioural measures of appetite are summarized in Table 8.4.

Table 8.4: All Systematic Significant Results in the Behavioural Measures of Appetite - All Participants, (including meals where significant results were found).

	Gender	Consumer	Preload	Consumer by Preload #
Test Meal Intake -Weight Consumed (gram.)				
Individual				
Cumulative	**M > F (all)**			
Test Meal Intake -Energy Consumed (kcal.)				
Individual	M > F (lunch, eve)			LC: W = AS = NS HC: W < AS = NS (lunch)
Cumulative	**M > F (all)**			LC: W = AS = NS HC: W < AS = NS (tea)
Total Energy Intake (kcal.)				
Cumulative	As Above		**W = AS < NS (all)**	LC: W = AS = NS (lunch, HC: W < AS = NS tea)
Test Meal Intake -Approximate Proportions of All Macronutients Consumed (%kcal.)				
Individual		LC > HC (lunch, eve)* LC < HC (day 2)		
Cumulative		**LC > HC (all)**		

Effects of Gender: M = Male Participants, F = Female Participants:
Effects of Consumer: LC = Low Consumers, HC = High Consumers:
Effects of Preload: W = Water, AS = Artificially Sweetened Drink, NS = Naturally Sweetened Drink.
*Effects of Macronutrients Consumed were found only in Protein
No Gender by Consumer Interactions, Gender by Preload Interactions or Gender by Consumer by Preload Interactions were found.

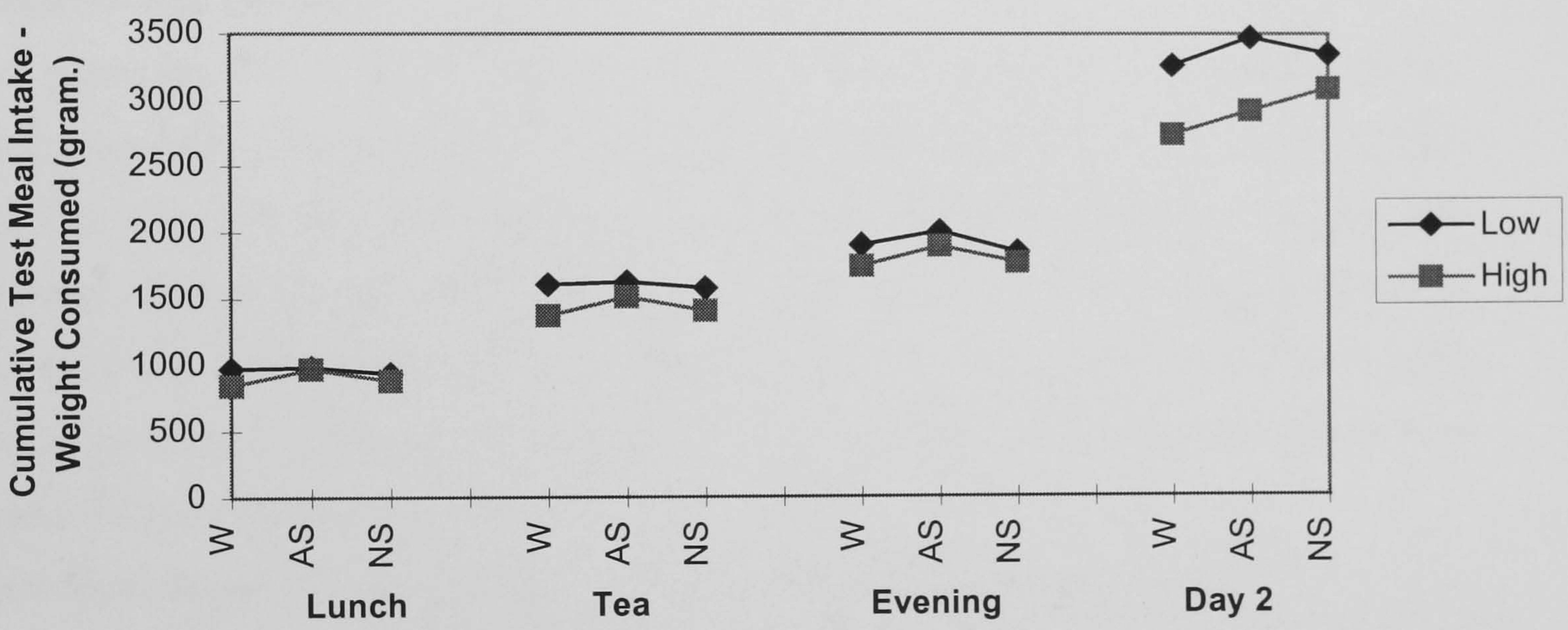
8.3.3.2. Male Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual Test Meal Intake, no significant differences were found between consumers (largest $F(1,13)=4.16$, $p=0.06$) or preloads (largest $F(2,26)=1.83$, $p=0.18$). No significant interactions were found (largest $F(2,26)=1.66$, $p=0.21$).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,13)=3.26$, $p=0.09$) or preloads (largest $F(2,28)=2.16$, $p=0.13$). No significant interactions were found (largest $F(2,26)=1.76$, $p=0.19$). The consistency of effects can be seen in Figure 8.6.

Figure 8.6: Diagram of Cumulative Test Meal Intake - Weight Consumed (gram.) - Male Participants. Line graphs are used to allow clear comparisons between consumers and between preloads

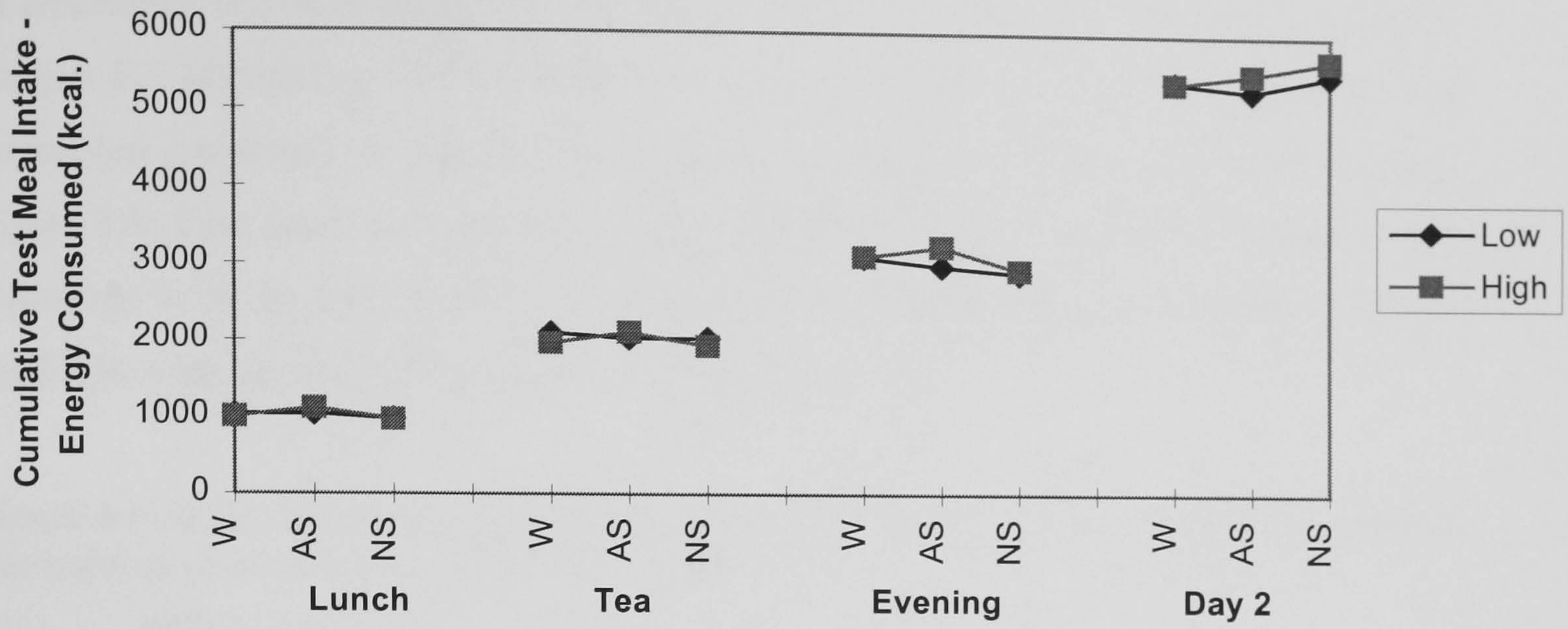


Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, no significant differences were found between consumers (largest $F(1,13)=0.60$, $p=0.45$) or preloads (largest $F(2,28)=1.74$, $p=0.19$). No significant interactions were found (largest $F(2,25)=1.11$, $p=0.35$).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=0.07$, $p=0.80$) or preloads (largest $F(2,28)=1.46$, $p=0.25$). No significant interactions were found (largest $F(2,28)=0.94$, $p=0.40$). The consistency of effects can be seen in Figure 8.7.

Figure 8.7: Diagram of Cumulative Test Meal Intake - Energy Consumed (kcal.) - Male Participants. Line graphs are used to allow clear comparisons between consumers and between preloads



Total Energy Intake:

In Cumulative Total Energy Intake, effects of consumer remain as in test meal intake - energy consumed. Consistent significant differences were found between preloads (smallest $F(2,26)=3.82$, $p=0.04$). Male participants consumed more total energy on the days they received NS than on the days they received AS (smallest $t(15)=-2.36$, $p=0.21$) and than on the days they received W (smallest $t(14)=2.48$, $p=0.03$). No significant differences were found between W and AS (largest $t(15)=1.30$, $p=0.21$). No significant interactions were found (largest $F(2,28)=0.94$, $p=0.40$).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no significant differences were found between consumers (largest $F(1,12)=2.39$, $p=0.15$) or preloads (largest $F(2,26)=3.13$, $p=0.06$). No interactions were found (largest $F(2,24)=0.60$, $p=0.56$).

In cumulative test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no significant differences were found between consumers (largest $F(1,24)=2.43$, $p=0.15$) and no systematic differences were found between preloads. No interactions were found (largest $F(2,26)=1.41$, $p=0.26$).

Summary:

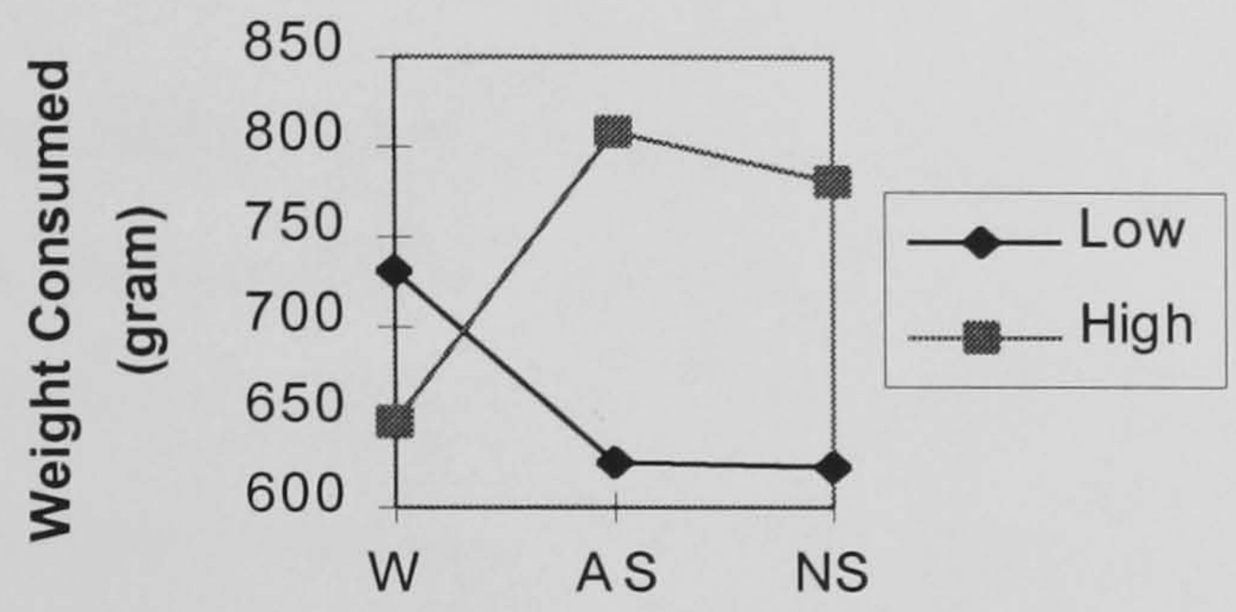
No significant differences between consumers or between preloads were found in male participants in any of the behavioural measures of appetite.

8.3.3.3. Female Participants

Test Meal Intake - Weight Consumed:

In Individual Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=3.81$, $p=0.07$) or preloads (largest $F(2,28)=0.93$, $p=0.41$). One significant interaction (consumer by preload) was found in lunch intake ($F(2,28)=7.42$, $p=0.003$) (see Figure 8.8). Low consumers consumed significantly <u>less</u> weight of food following AS than following W ($t(7)=-2.47$, $p=0.03$); high consumers consumed significantly <u>more</u> weight of food following AS than following W ($t(7)=2.44$, $p=0.04$).

Figure 8.8: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - Female Participants - Lunch Intake - Consumer by Preload



In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=2.93$, $p=0.11$) or preloads (largest $F(2,28)=0.80$, $p=0.46$). Significant interactions (consumer by preload) were found after tea ($F(2,28)=6.91$, $p=0.004$) and at the end of Day 1 ($F(2,28)=3.91$, $p=0.03$) (see Figures 8.9 and 8.10). Low consumers consumed a <u>similar</u> weight of food following AS and W following tea ($t(7)=-1.70$, $p=0.13$), and at the end of Day 1 ($t(7)=3.53$, $p=0.01$); high consumers consumed significantly <u>more</u> weight of food following AS than following W at the end of Day 1 ($t(7)=3.12$, $p=0.02$), and showed a similar trend following tea ($t(7)=-1.51$, $p=0.17$). The consistency of effects can be seen in Figure 8.11.

Figure 8.9: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - Female Participants - Cumulative Intake following Tea - Consumer by Preload

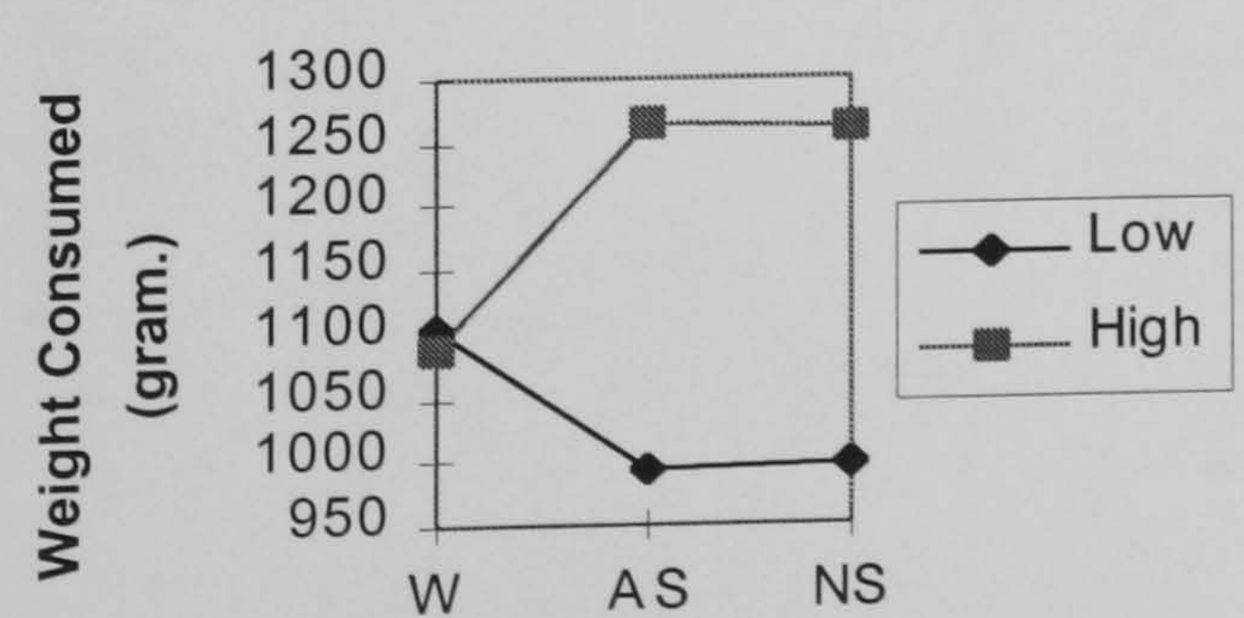


Figure 8.10: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - Female Participants - Cumulative Intake at the end of Day 1 - Consumer by Preload

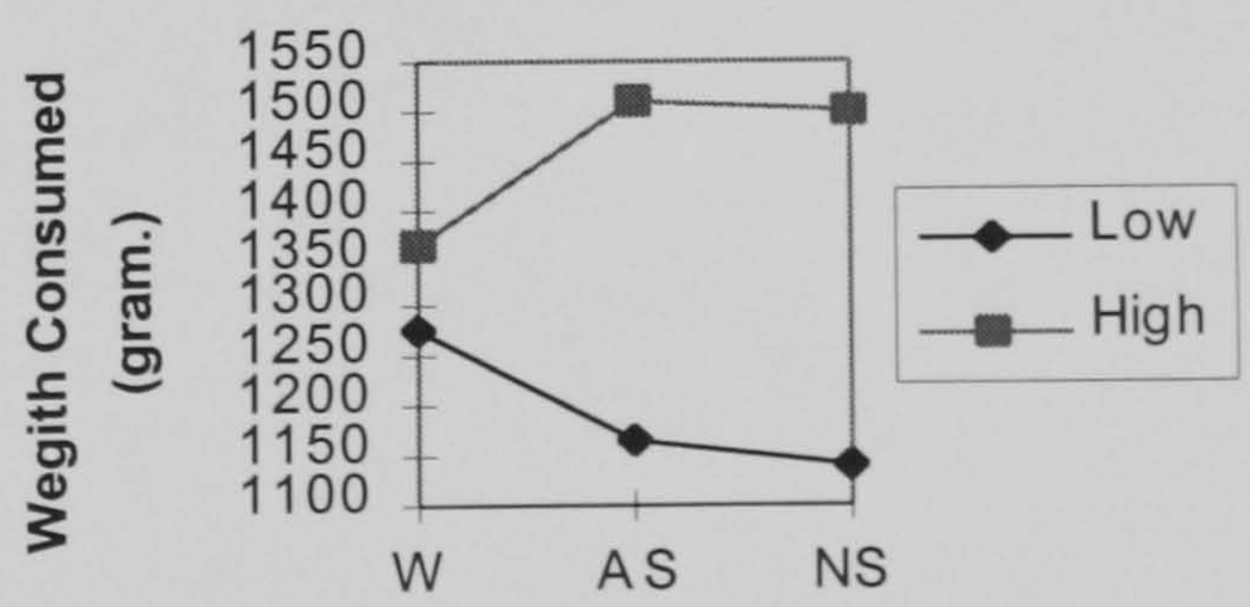
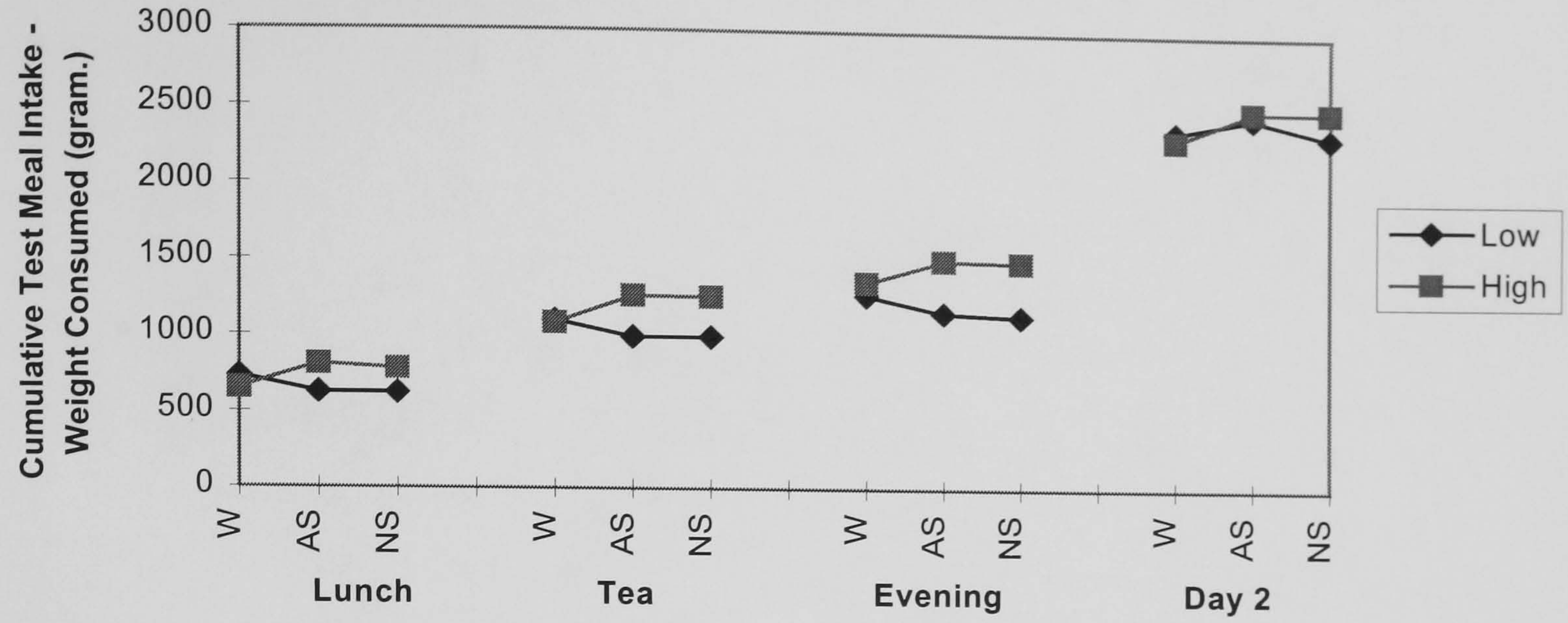


Figure 8.11: Diagram of Cumulative Test Meal Intake - Weight Consumed (gram.) - Female Participants. Line graphs allow clear comparisons between consumers and preloads



Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, no significant differences were found between consumers (largest F(1,13)=3.50, p=0.08) or preloads (largest F(2,28)=0.92, p=0.41). One significant interaction (consumer by preload) was found in lunch intake (F(2,28)=3.93, p=0.03) (see Figure 8.12). Low consumers consumed significantly <u>less</u> energy following AS than following W (t(7)=-3.41, p=0.01); high consumers consumed significantly <u>more</u> energy following AS than following W (t(7)=2.51, p=0.04).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest F(1,13)=3.29, p=0.09) or preloads (largest F(2,28)=0.89, p=0.42). Significant interactions (consumer by preload) were found following tea (F(2,28)=3.64, p=0.04) (see Figure 8.13). Low consumers consumed a <u>similar</u> amount of energy following AS and following W (t(7)=-1.45, p=0.19); high consumers consumed significantly <u>more</u> energy following AS than following W (t(15)=3.33, p=0.01). The consistency of effects can be seen in Figure 8.14.

Figure 8.12: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - Female Participants - Lunch Intake - Consumer by Preload

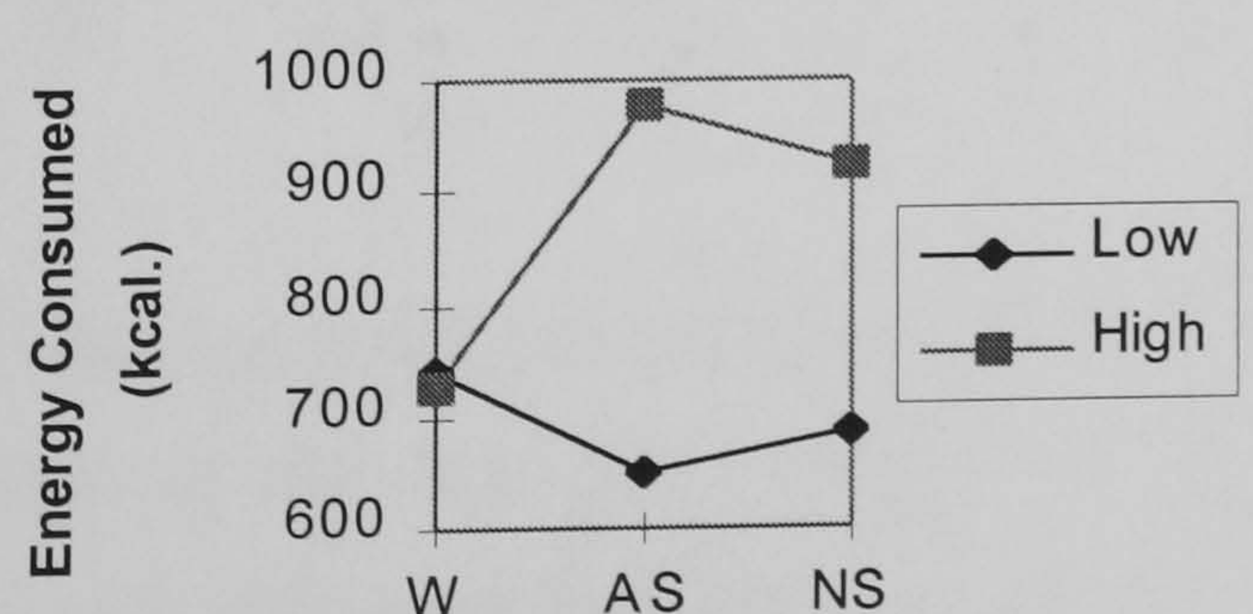


Figure 8.13: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - Female Participants - Cumulative Intake following Tea - Consumer by Preload

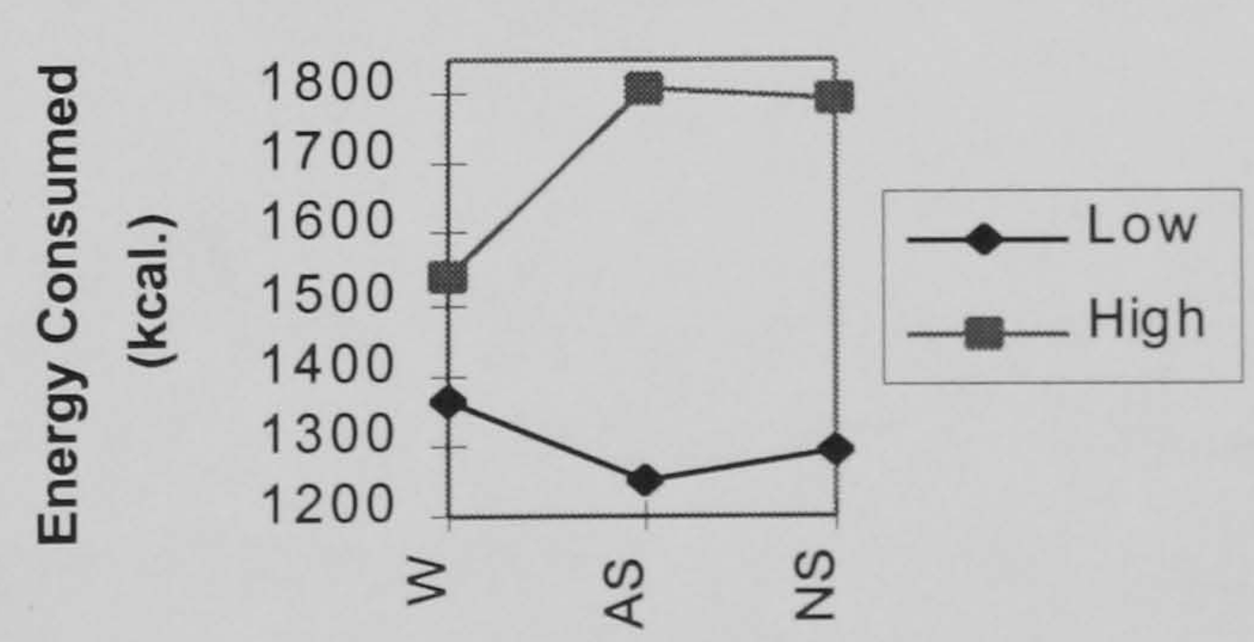
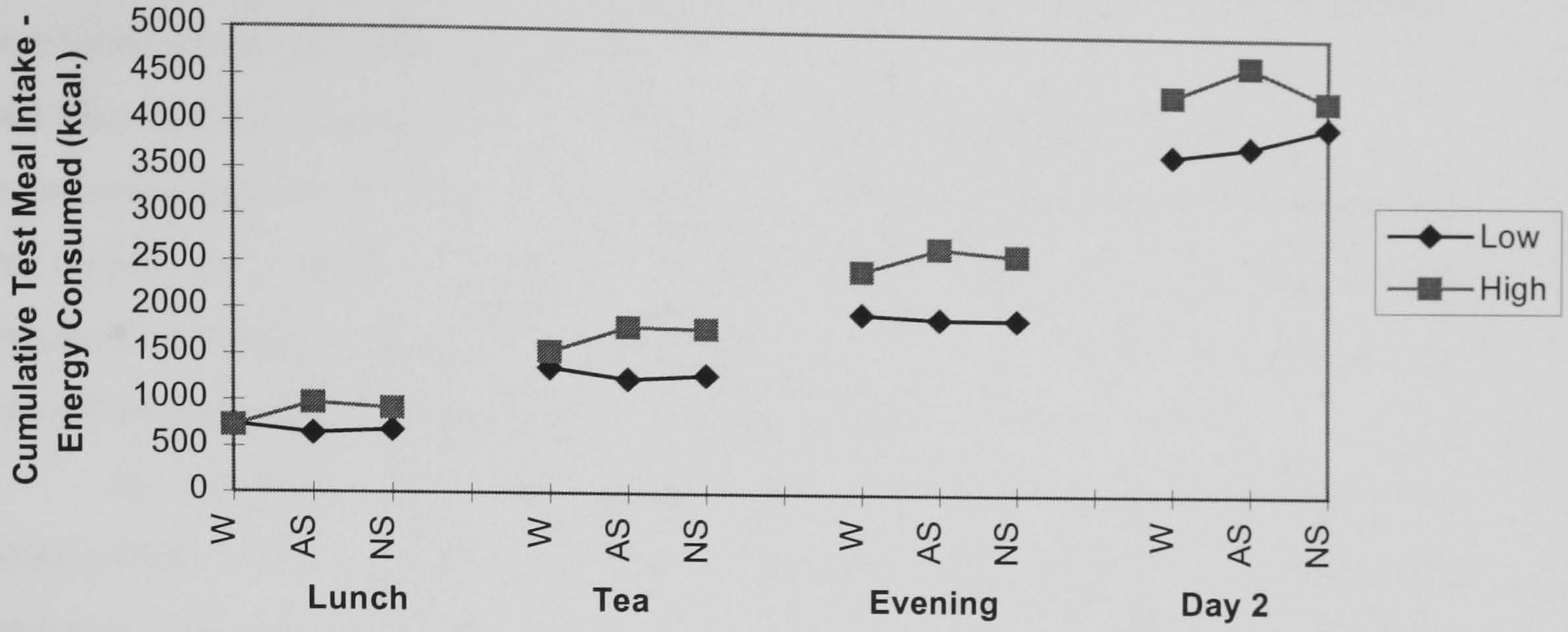


Figure 8.14: Diagram of Cumulative Test Meal Intake - Energy Consumed (kcal.) - Female Participants. Line graphs allow clear comparisons between consumers and preloads



Total Energy Intake (kcal.):

In Cumulative Total Energy Intake, effects of consumer remain as in test meal intake - energy consumed. Consistent significant differences were also found between preloads (smallest $F(2,28)=3.75$, $p=0.04$). Female participants consumed more total energy on the days they received NS than on the days they received AS (smallest $t(15)=-3.58$, $p=0.003$) or W (smallest $t(15)=2.57$, $p=0.02$). Differences between NS and AS were not significant following Day 2 ($t(15)=-1.67$, $p=0.12$). No significant differences were found between W and AS (largest $t(15)=1.35$, $p=0.20$). Significant interactions (consumer by preload) were found following lunch ($F(2,28)=3.93$, $p=0.03$) and following tea ($F(2,28)=3.64$, $p=0.04$) (see Figures 8.15 and 8.16).

Figure 8.15: Interaction Graph for Total Energy Intake (kcal.) - Cumulative Intake following Lunch - Consumer by Preload

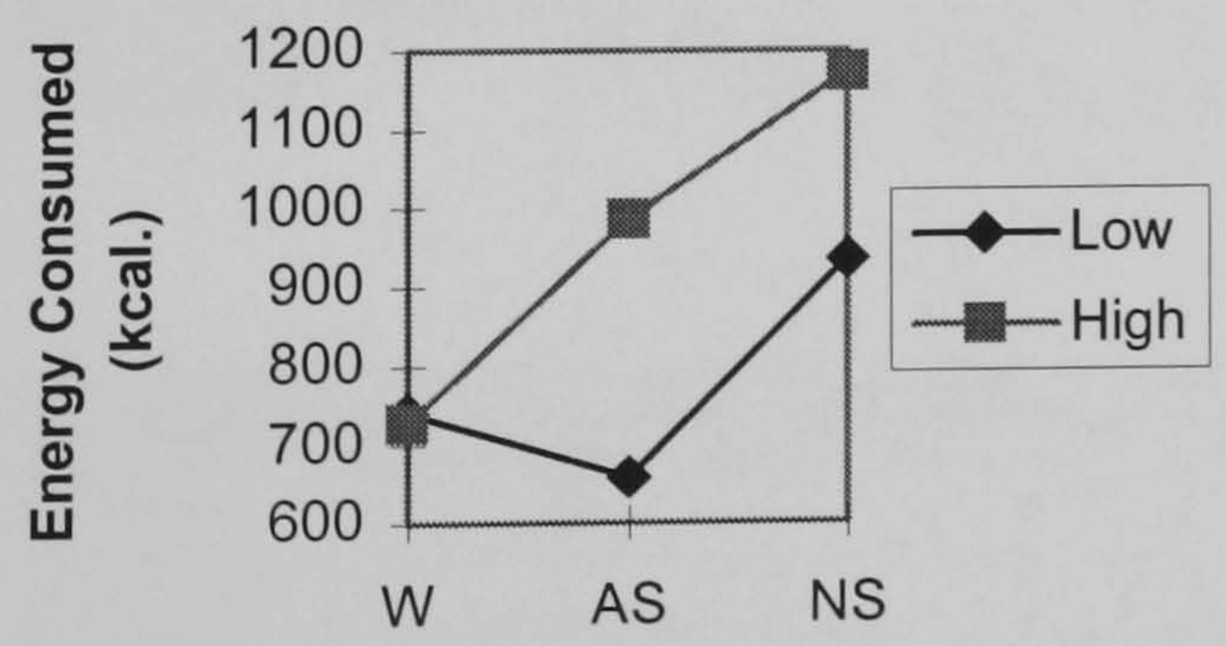
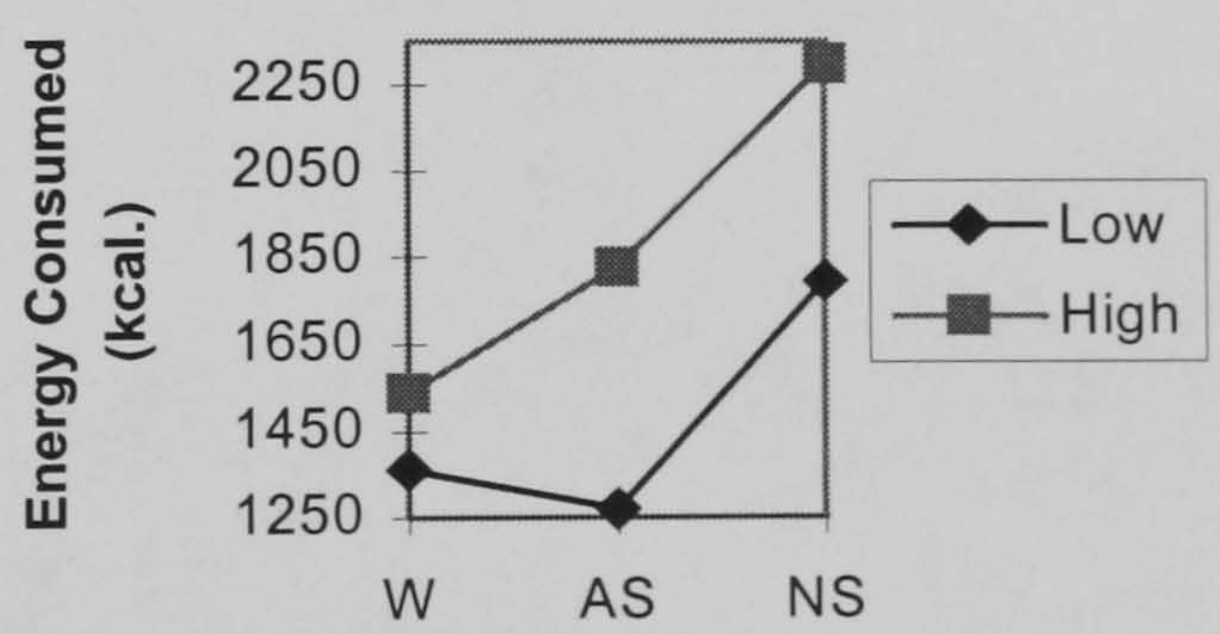


Figure 8.16: Interaction Graph for Total Energy Intake (kcal.) - Cumulative Intake following Tea - Consumer by Preload



Following lunch, low consumers consumed <u>less</u> total energy on the days they received AS than on the days they received W ($t(7)=-3.04$, $p=0.02$); high consumers consumed significantly <u>more</u> total energy on the days they received AS than on the days they received W ($t(7)=2.68$, $p=0.03$). Following tea, low consumers consumed a <u>similar</u> total amount of energy on the days they received AS and on the days they received W ($t(15)=-1.20$, p=0.27); high consumers consumed significantly <u>more</u> total energy on the days they received AS than on the days they received W ($t(7)=3.58$, $p=0.01$). No other interactions were found (largest $F(2,28)=0.84$, $p=0.44$).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no systematic significant differences were found between consumers. No significant differences were found between preloads (largest $F(2,24)=1.72$, $p=0.20$). No interactions were found (largest $F(2,26)=1.96$, $p=0.16$).

In cumulative test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no systematic significant differences were found between consumers. No significant differences were found between preloads (largest $F(2,28)=0.62$, $p=0.55$). No systematic interactions were found.

Summary:

All systematic significant results in female participants in the behavioural measures of appetite are summarized in Table 8.5.

Table 8.5: All Systematic Significant Results in the Behavioural Measures of Appetite - Female Participants (including meals were significant results were found).

	Consumer	Preload	Consumer x Preload
Test Meal Intake -Weight Consumed (gram.)			
Individual			LC: W = AS = NS HC: W < AS = NS (lunch)
Cumulative			LC: W = AS = NS HC: W < AS = NS (tea, day 1)
Test Meal Intake -Energy Consumed (kcal.)			
Individual			LC: W = AS = NS HC: W < AS = NS (lunch)
Cumulative			LC: W = AS = NS HC: W < AS = NS (tea)
Total Energy Intake (kcal.)			
Cumulative	As Above	W = AS < NS (all on day 1) W = AS = NS (day 2)	LC: W > AS = NS HC: W < AS = NS (lunch) LC: W = AS = NS HC: W < AS = NS (tea)
Test Meal Intake -Approximate Proportions of All Macronutients Consumed (%kcal.)			
Individual			
Cumulative			

Effects of Consumer: LC = Low Consumers, H = High Consumers,
Effects of Preload: W = Water, AS = Artificially Sweetened Drink, NS = Naturally Sweetened Drink.

8.4. DISCUSSION

Analysing all participants together, differences were found in this study, between genders, between consumers and between preloads. All effects found between consumers and preloads however, can be attributed to the female participants. No effects were found in male participants.

8.4.1. FEMALE PARTICIPANTS

In female participants, the main findings of this study are:

- Low consumers of artificially-sweetened beverages consumed <u>similar</u> amounts or significantly <u>less</u> in test meal intake (weight of food, energy) following an AS preload than following a W preload.
- High consumers of artificially-sweetened beverages consumed significantly <u>more</u> in test meal intake (weight of food, energy) following an AS preload than following a W preload.
- All participants consumed <u>similar</u> amounts in test meal intake (weight of food, energy) following an AS preload and an NS preload.

8.4.1.1. Effects on Appetite of Sweetness (W vs. AS)

The effects on appetite of sweetness without energy have previously been widely researched (see Chapter 2). Sweetness without energy can be expected to result in an increase in subsequent appetite as a result of the reliable association between sweetness and energy. Furthermore, an increase in appetite in response to sweetness without energy can be expected to occur in all individuals in whom sweetness and energy are normally reliably experienced in association - i.e. in all low consumers of sweetness without energy.

In this study however, low consumers did not demonstrate an increase in appetite in response to sweetness without energy (W vs. AS), or demonstrated a reduction in appetite.

The absence of effects of sweetness may be attributed to the methodological procedure of the study. All sweetness/energy manipulations were provided at least 2 hrs prior to the subsequent behavioural measurement of appetite. This time delay was included in the design of the study to minimize the effects on appetite of the artificial sweeteners contained in the artificially-sweetened (AS) preload. Two hours however, between the consumption of a preload and the subsequent measurement of appetite is a long time considering the length of time for which tastes are typically experienced, and the length of time for which the subsequent physiological effects of that taste will be anticipated. The taste of sweetness, as received in 330ml of drink is thought to dissipate from the mouth within 30 min. (Booth, 1988; Birch, 1987). The typical length of time between experiencing the taste and some of the positive subsequent physiological effects of a food item is normally far shorter than this (Carlson, 1986). Two hours after experiencing a sweet taste, that taste may no longer exert effects on appetite. Considering the absence of effects of sweetness without energy, it should also be noted that two of the four drinks on each study day were consumed immediately after a meal. The close temporal proximity between the sweetness of the drink and the energy of the meal may have considerably lessened the impact of the sweet/low energy drink.

The small decrease in appetite in the low consumers following the AS preload is most plausibly explained as a result of the ingestion of aspartame. Aspartame has previously been reported to decrease appetite (see Chapter 2, section 2.2.4.1). The ingestion of aspartame may also explain the decreased appetite in response to sweetness without energy reported by Guss, Pi-Sunyer and Kissileff (1994) - the only previous study to also report a decrease in appetite following sweetness without energy (see Chapter 2).

8.4.1.2. Effects on Appetite of Sweetness with and without Energy (AS vs. NS)

The comparison of sweetness with and without energy has also been previously widely researched (see Chapter 2). Compared to sweetness without energy, sweetness with energy is expected to result in a decrease in subsequent appetite as a result of the included energy.

In this study however, both high and low consumers of artificially-sweetened beverages demonstrated no response to energy in subsequent test meal intake. A small trend toward reduced intake was found, but was not significant. All consumers also demonstrated a significant increase in the amount of total energy consumed on the days they received the sweet/high energy (NS) preload. The energy provided in the drinks was clearly not compensated for in subsequent test meal intake.

The absence of effects in response to energy can also be explained as a result of the methodological design of the study. Sweetness and energy manipulations on all occasions were provided in a drink form. Drinks were used as realistic and liked examples of these nutritional manipulations. Nutritional manipulations provided in drink form, however, have previously been suggested to have a lesser effect on subsequent appetite than those provided in solid form (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996; Rogers, Pleming and Blundell, 1990). It has also been previously suggested that energy in a drink form will only substantially affect appetite within the hour (Booth, 1988; Booth, 1987). All energy manipulations in this study were provided at least 2 hrs prior to subsequent behavioural measures of appetite. The lack of effects of energy may also have been due to the 2 hr. time delay between preload consumption and subsequent behavioural measures of appetite.

8.4.1.3. High and Low Consumers of Artificially-Sweetened Beverages

From the discussion above, the effects on appetite found in this study are unlikely to be a result of the sweetness/energy manipulations as intended.

Unrelated to intended manipulations however, differences between low and high consumers of artificially-sweetened beverages were found in this study. Compared to the low consumers, habitual high consumers of artificially-sweetened beverages demonstrated increases in appetite in response to the sweet AS and NS preloads. These increases in appetite are most plausibly explained as a result of differences between sweet and non-sweet preloads in palatability and familiarity, and the differences in perceptions of palatability between consumers. All preloads were designed to be equally palatable and familiar, and were considered equally palatable and familiar prior to the study by piloting in the general population. To self-selecting habitual high consumers of artificially-sweetened beverages, however, sweet drinks are likely to be perceived as more palatable than non-sweet drinks (e.g. Laeng, Berridge and Butter, 1993; Conner and Booth, 1988). Palatability can be very influential in appetite regulation. Increases in the palatability of food items have been found not only to increase immediate consumption levels (e.g. Yeomans, Gray, Mitchell and True, 1997; Yeomans, 1996), but also to increase subsequent subjective measures of appetite (e.g. Hill, Magson and Blundell, 1984) and subsequent food intake (e.g. Perez, Dalix, Guy-Grand and Bellisle, 1994; Rogers and Schutz, 1992). Perceptions of palatability may also be increased in the habitual high consumers of artificially-sweetened beverages by increased levels of exposure to and familiarity with sweet drinks. Increased exposure and familiarity have previously been suggested to increase palatability (Pliner, Pelchat and Grabski, 1993; Pliner, 1982).

Unrelated to the intended manipulations, trends were also found in this study, where female high consumers reported higher levels of thirst than low consumers. This effect is surprising. Water was freely supplied in excess during all meals and all participants were free to consume as much water as they wished throughout the day. Increases in thirst in the high consumers may thus be indicative not of increases in thirst but of an unwillingness to satisfy that thirst with water. Alternatively increases in thirst may be indicative of nothing more than differences between consumers in habitual fluid consumption levels or differences in extreme measures of thirst (V.A.S. anchors on which to rate levels of thirst) (see Hill, Blundell and Rogers, 1995).

8.4.2. MALE PARTICIPANTS

In male participants, no differences were found between consumers or between preloads.

The lack of observed differences between consumers may be a result of an actual lack of differences. In female participants however, differences were found between high and low consumers of artificially-sweetened beverages. This difference between males and females may simply be a reflection of an increased sensitivity to nutritional challenges by female participants. Increased sensitivity however, is commonly attributed to males, not to females (see Rolls, Castellanos, Halford, Kilara, Panyam, Pelkman, Smith and Thorwart, 1998; Rolls, Fedoroff and Guthrie, 1991). Alternatively, in explaining the differences in the female high and low consumers as a result of palatability, the absence of differences between male high and low consumers may be a result either of perceptions of similar levels of palatability for sweet and non-sweet drinks by the males or a less refined perception of palatability in males. A less refined perception of taste has previously been suggested in males compared to females, in detection of differing sweetness intensities (e.g. Laeng, Berridge and Butter, 1993; Tordoff and Alleva, 1990), but taste perception has also previously been suggested to have little effect on food preferences (palatability) and appetite (Tepper, Hartfiel and Schneider, 1996). Evidence also exists however, suggesting that taste is also a less important influence in appetite in males than in females (Tuomisto, Tuomisto, Hetherington and Lappalainen, 1988; Yeomans, 1996; Zylan, 1996; Beatty, 1982). The lesser effects of sweetness in male participants in this study, may be explained by the lesser detection and lesser importance of taste in appetite.

The lack of effects of the preloads can be attributed, as in the female participants, to the methodological procedure of the study.

8.4.3. ADDITIONAL FINDINGS

A number of other effects were also found in this study. Firstly, differences were found between genders, irrespective of consumer group. Males consumed significantly more in test meal intake (weight of food, energy) than females. This effect is not surprising and has been frequently reported previously (e.g. Rolls, Fedoroff and Guthrie, 1991).

Secondly, in comparing high and low consumers, a trend can be seen towards general increased levels of appetite in the high consumers. This may be a demonstration of a habitual increase in appetite in the high consumers. Further investigation into this suggestion however is obviously required before conclusions can be drawn.

Thirdly, no significant differences between consumers or preloads were found in any of the subjective measures of appetite. This may be due to the small size of effects on appetite of sweetness, energy or palatability compared to the effects on appetite of the volume and weight of preload consumed, and the general effects on appetite of time. Differences between subjective and behavioural measures of appetite may be a result of the constraints imposed on participants due to the experimental situation.

Significant differences were also not found in measures of proportions of energy consumed from each macronutrient. This can be attributed to the relatively consistent macronutrient content of the food items provided in all test meals/periods. Significant differences were found between consumers in proportions of energy consumed from protein, but are likely to be a result of the selection of food items provided. The differences found between consumers in proportions of energy consumed from protein are difficult to interpret meaningfully due to the absence of any corresponding differences in proportions of energy consumed from carbohydrate and fat.

8.5. SUMMARY

In summary, this study has uncovered some interesting differences between high and low consumers of artificially-sweetened beverages. In female participants, low consumers of artificially-sweetened beverages consumed a similar quantity of food following all three preloads, high consumers consumed significantly more following the two sweetened drink preloads. In male participants, no differences were found. These effects however, are unlikely to be a result of the manipulations of sweetness or energy as intended. Manipulations of sweetness and energy are considered to have been ineffective in appetite regulation due to the absence of responses to sweetness and energy in the low consumers of artificially-sweetened beverages in this study. This lack of effect is attributed to the two hour time delay between the consumption of the preload and the subsequent measurement of appetite, and is also possibly related to the close temporal proximity between preload consumption and previous meal. These small design problems can be easily amended. The appetitive responses to sweetness and energy in habitual high and low consumers of sweetness without energy will be re-investigated. The differences between female consumers found in this study are most plausibly explained as a result of differences in perceptions of palatability between preloads and between consumers. The lack of effects in males and differences between males and females can be explained by a decreased importance of taste in appetite in males compared to females.

STUDY 4:
UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE:
RESPONSES TO SWEETNESS AND ENERGY WHEN CONSUMED AS A DRINK: REPETITION

ABSTRACT

This study re-investigates the responses to sweetness and energy in male and female, high and low consumers of artificially-sweetened beverages. Subjective and behavioural appetite was measured following 3 sweetness/energy preload manipulations (non-sweet/low energy, sweet/low energy, sweet/high energy). In subjective measures of appetite, no differences were found between consumers. In behavioural measures, the majority of effects in all participants are attributed to the male participants. In female participants, low consumers consumed more following the sweet/low energy preload, than following the non-sweet/low energy preload or the sweet/high energy preload; low consumers demonstrated responses to sweetness and energy. High consumers consumed significantly more than low consumers irrespective of preload, and consumed more following the low energy preloads than following the high energy preload; high consumers demonstrated increases in appetite and responses to energy, but no response to sweetness. In male participants, low consumers of artificially-sweetened beverages consumed similar amounts following all preloads; low consumers demonstrated no response to sweetness or energy. High consumers consumed more following the sweet/low energy preload compared to the non-sweet/low energy preload and the sweet/high energy preload; high consumers demonstrated responses to sweetness and energy. Due to the very high overall consumption levels in the low consumers, effects may have been masked. It is assumed that all male participants demonstrated responses to sweetness and energy; no differences were found between consumers. Increases in appetite in female participants may be explained as a result of the uncoupling of sweetness and energy (a persistence of the sweetness-energy relationship), and associations with the self-selection of a high consumption of artificial sweeteners. Differing responses to sweetness and energy may demonstrate an extinction of the sweetness-energy relationship.

8.6. INTRODUCTION

In the previous study (Study 3), responses to sweetness and energy in habitual high and low consumers of sweetness without energy were investigated by measuring responses to three sweetness/energy preload manipulations. The preload manipulations however, were considered to be ineffective in the study, as a result of the long two hour time delay between preload consumption and subsequent behavioural measurement of appetite, and also possibly as a result of the close temporal proximity between preload consumption and consumption of the previous meal .

Problems of time delay can be amended: either preload consumption can be moved closer to the subsequent behavioural measurement of appetite - i.e. the time of preload consumption can be moved closer to the time of the test meal; or the subsequent behavioural measurement of appetite can be moved closer to preload consumption - i.e. measured inter-meal snack intake can occur alongside the inter-meal preload consumption. Problems of temporal proximity can be amended by allowing a distinct time interval between consumption of the preload and consumption of the previous meal.

In the previous study (Study 3), the time delay between preload consumption and subsequent behavioural measurement of appetite was chosen to minimize the effects on appetite of the artificial sweeteners in the artificially-sweetened drink preload. Potential effects may still occur. In this study, time delay between preload consumption and the subsequent behavioural measures of appetite will remain as long as possible as in the last study, but preload consumption will be distinctly separate from previous meals. Inter-meal snacking will also be permitted. Inter-meal snacking also allows participants to respond to the preloads at any chosen time, as opposed to at fixed meal times. Inter-meal snacking however may slightly compromise the concurrent tracking of appetite by subjective measures. Few effects were found in the subjective measures of appetite however, in the previous study. Any potential effects will be taken into consideration here when interpreting all findings in subjective measures.

Attempts were also made, in this study, to minimize differences between preloads and consumers in the perceived palatability of the sweet preload drinks. The preload drinks used in this study were identical to those used previously to allow accurate comparison between the studies. In this study however, participants were only recruited if prior to the study, they rated sweet blackcurrant flavoured drinks as moderately palatable. Participants rating the sweet preload drinks as extremely palatable were not included in the study.

8.6.1. AIMS

This study aims to re-investigate the appetitive responses to sweetness and energy in habitual high and habitual low consumers of sweetness without energy. The study will be a repetition of the previous study, but will also include inter-meal snacking and a slight change in the timing of preload consumption.

8.7. METHOD

8.7.1. DESIGN

The study uses a 2 x 2 x 3 mixed design, investigating gender (2 levels), consumer type (2 levels), and sweetness/energy manipulation (3 levels). The study was conducted using a preloading procedure, where sweetness/energy manipulation was given as a preload and appetite was subsequently measured using subjective and behavioural measures.

8.7.2. CONSUMERS

Two independent groups of consumers participated in the study - habitual high consumers of artificially-sweetened beverages and habitual low consumers of artificially-sweetened beverages. Habitual high consumers were required to be consuming ≥ 825 ml (artificially-sweetened beverages)/day. Habitual low consumers were required to be consuming 0 ml (artificially-sweetened beverages)/day. Consumption levels of all artificially-sweetened beverages were reported by all participants on a self-report Drinks F.F.Q., completed prior to inclusion in the study (see Appendix 8.1). Equal numbers of males and females participated in the study.

In total, 16 habitual high consumers (8 male and 8 female) and 16 habitual low consumers (8 male and 8 female) took part in the study. Prior to the start of the study, all participants were measured for calculation of B.M.I. and completed the D.E.B.Q., as a measure of dietary restraint. Consumer groups were matched as closely as possible on B.M.I. and dietary restraint (D.E.B.Q.-R.) scores. All participants were familiar with and moderately liked all foods in the study. None of the participants extremely liked any of the foods in the study, to lessen any potential effects of palatability. None of the participants were informed of the exact hypotheses of the study. The participants in this study were recruited independent of the previous study. Participant characteristics are displayed in Table 8.6.

Table 8.6: Participant Characteristics (mean (standard deviation))

Participants	Artificially-Sweetened Beverage Consumption (ml/day)	B.M.I. (kg/m^2)	D.E.B.Q. - R. score
Low - Male (N=8)	0.0 (0.0)	20.6 (2.5)	17.4 (5.3)
Low - Female (N=8)	0.0 (0.0)	21.9 (1.7)	25.0 (4.1)
High - Male (N=8)	1588.5 (850.9)	24.1 (3.3)	23.5 (7.1)
High - Female (N=8)	1604.4 (1126.4)	24.2 (3.5)	31.6 (6.8)

8.7.3. SWEETNESS / ENERGY MANIPULATIONS

The sweetness / energy manipulations were given as a preload drink. The three manipulations used were:

- non sweet / low energy - water (W) - 0 kcal/330ml
- sweet / low energy - artificially-sweetened drink (AS) - 5 kcal/330ml
- sweet / high energy - naturally-sweetened drink (NS) - 125 kcal/330ml

Exact details of the preload drink recipes are given in Appendix 6.1. The two sweet drink preloads were piloted prior to investigation to ensure equal palatability and sweetness. All preloads were given as four 330ml drinks, to be consumed throughout the day. Four drinks of 330ml allowed a high exposure (frequency and quantity) of each preload. The timing of consumption of each drink was fixed at approximately 3hrs and 1.5hrs prior to the following test meal (see section 8.7.5). The timing of the consumption of the four drinks was specified to minimize the effects on appetite of the actual artificial sweeteners and to control any potential differential effects between participants (see Chapter 2, section 2.2.4). Small differences in the timing of preload consumption between this study and the previous study were considered negligible in terms of the potential effects on appetite of the artificial sweeteners (see Stegink, 1984).

All participants experienced all three preloads, each on a separate study day, approximately one week apart. The order of presentation of the preloads was counter-balanced across all participants.

8.7.4 MEASURES OF SUBSEQUENT APPETITE

Subsequent appetite was measured using subjective and behavioural measures.

8.7.4.1. Subjective Measures

Subjective perceptions of appetite were measured using 100mm V.A.S. of Hunger, Desire to Eat, Fullness, Prospective Consumption, Thirst and Desire to Drink. Subjective appetite was measured throughout the day, as detailed in section 8.7.5.

8.7.4.2. Behavioural Measures

Behavioural expressions of appetite were measured using extent of consumption in six ad-libitum test meals/periods (test meal intake). Test Meal Intake for all test meal/periods was measured as weight of food consumed (gram.), energy consumed (kcal.) and proportions of all macronutrients consumed (% kcal.). The test meals/periods used were morning snacks, lunch, afternoon snacks, tea, evening snacks, and the following day. The morning snackbox was composed of: individual packets of crisps, individual packets of cheese biscuits, individual packets of cheese crackers, individual packets of chocolate biscuits, individual packets of cookies and individual packets of plain sweet biscuits. Lunch was composed of: cream cheese or turkey sandwiches, coleslaw, cheese and tomato pizza, confectionery, strawberry yoghurt and water. The afternoon snackbox was composed of: individual packets of crisps, individual packets of cheese biscuits, individual packets of cheese crackers, individual packets of chocolate biscuits, individual packets of cookies and individual packets of plain sweet biscuits. Tea was composed of: vegetable lasagne, peas, chocolate digestive biscuits, apples and water. The evening snackbox was composed of:

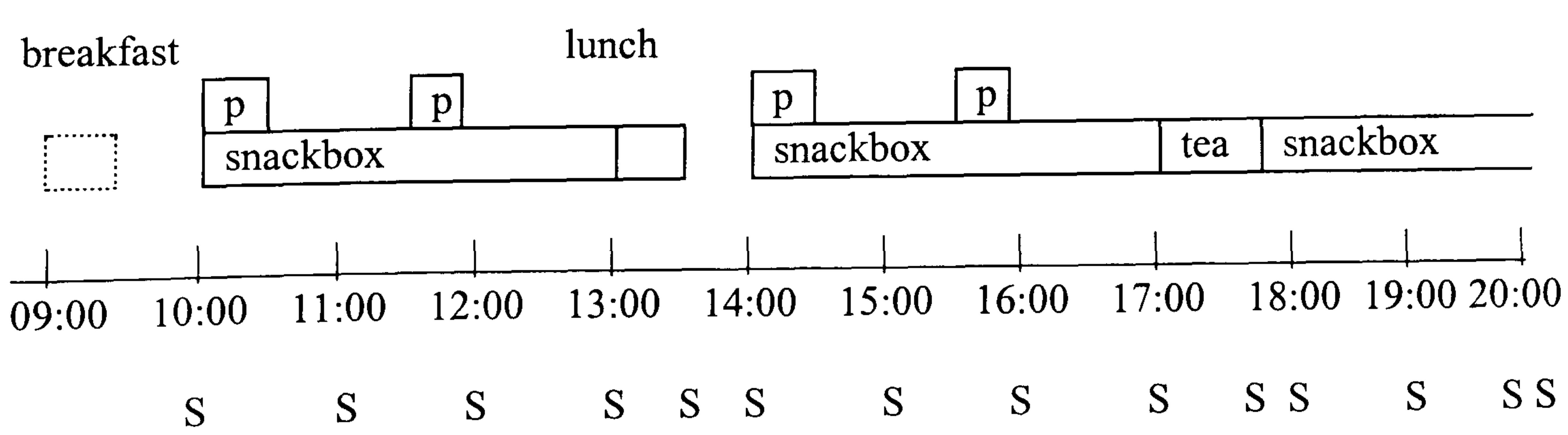
bread rolls, margarine portions, cheese portions, jam portions, individual packets of crisps, individual packets of biscuits, apples and yoghurts. All foods were served in excess. Recipes and the energy and macronutrient content of all foods can be found in Appendix 8.14. All drinks consumed in conjunction with the snackbox were recorded by the participants. On the following day, all foods and drinks consumed were recorded by the participants in a 'portion-size' food diary.

Results are provided for each individual test meal - Individual Test Meal Intake (morning snack intake, lunch intake, afternoon snack intake, tea intake, evening snack intake, Day 2 intake), and for a summation of all test meal intakes throughout the day - Cumulative Test Meal Intake (following morning snacks, following lunch, following afternoon snacks, following tea, end of Day 1, end of Day 2). Total Energy Intake (kcal.) was also measured cumulatively as energy intake from the test meal plus energy intake from the preload drinks.

8.7.5. PROCEDURE

A time line of each study day is shown in Figure 8.17. On each study day all participants were required to be in the Human Nutrition Unit from 10:00 to 10:15, from 13:00 to 13:45 and from 17:00 to 17:45. At all other times, participants were free to behave as normal, but were instructed to consume the preload drinks in full at the specified times, and to refrain from eating or drinking anything else except the snacks provided and water. All participants consumed their own breakfast at home on each day, were instructed to keep each breakfast as standard as possible on each study day and were asked to record each breakfast on arrival in the unit. Any differences in breakfast consumption were calculated using food composition tables and were added to morning snack intake. All study days were identical excepting the preload drink received.

Figure 8.17: Time Line of Each Study Day in Study 4.



p = Consumption of Preload Drinks
S = Completion of Subjective Measures of Appetite

8.7.6. ANALYSIS

Participant Characteristics: Prior to analysis of the dependent measures in this study, all consumer groups were compared in terms of artificially-sweetened beverage consumption, B.M.I. and Dietary Restraint Score. The groups of high and low consumers were designed to differ in artificially-sweetened beverage consumption. All groups were designed to be similar in B.M.I. and Restraint. If differences were found between consumer groups, or if a significant relationship was found between B.M.I. and/or Dietary Restraint and Total Test Meal Intake on Day 1 (kcal.), B.M.I. and/or Dietary Restraint Score were included in all analyses as covariates. Participant characteristics were analysed by 1-way ANOVA (4 groups) and Pearson Product Moment Correlations.

Subjective Measures of Appetite: All subjective measures of appetite are described as temporal profiles and were analysed using 4-way mixed ANCOVA (gender by consumer by preload by time, covariate - dietary restraint score). Data for male participants were also analysed separately using 3-way mixed ANOVA (consumer by preload by time). Data for female participants were analysed separately using 3-way mixed ANCOVA (consumer by preload by time, covariate - dietary restraint score). Student-Newman-Keuls t-tests were used to investigate significant ANOVA/ANCOVA results. Due to the constraints of the statistical tests used, subjective ratings were collapsed across some time points and analyses for multi-way interactions were not always conducted.

Behavioural Measures of Appetite: Individual, Cumulative and Total Energy Intake were analysed using 3-way mixed ANCOVA (gender by consumer by preload, covariate - Dietary Restraint Score). Data for male participants were also analysed using 2-way mixed ANOVA (consumer by preload). Data for female participants were analysed using 2-way mixed ANCOVA (consumer by preload, covariate Dietary Restraint Score). Student-Newman-Keuls t-tests were used to investigate significant ANOVA/ANCOVA results. Data is missing for one male on Day 2, due to excess alcohol intake. Data is also recorded as missing in proportions of macronutrient consumed if nothing was consumed in a test meal/period.

Due to the amount of data collected, only systematic significant differences are reported below in the text. Significant differences were considered systematic if patterns of similar differences were found in related data (e.g. in lunch and tea intake). All significant differences are reported in the appendices, in all results tables.

8.8. RESULTS

8.8.1. PARTICIPANT CHARACTERISTICS

8.8.1.1. Artificially-Sweetened Beverage Consumption

High and low consumers were designed to differ in artificially-sweetened beverage consumption. Significant differences were found between consumer groups ($F(3,28)=13.64$, $p<0.001$). Male high consumers consumed more artificially-sweetened beverages than male and female low consumers (both: $t(14)=-5.28$, $p<0.001$). Female high consumers consumed more artificially-sweetened beverages than male and female low consumers (both: $t(14)=-4.03$, $p=0.001$). No differences were found between male and female high consumers ($t(14)=0.03$, $p=0.98$), or between male and female low consumers.

8.8.1.2. B.M.I.

High and low consumers were designed to be similar in B.M.I. No significant differences were found between consumer groups in B.M.I., although a trend was observed ($F(3,28)=3.06$, $p=0.05$; largest $t(14)=-2.37$, $p=0.03$ (adjusted significance)). No relationship was found between B.M.I. and total Test Meal Intake on Day 1 (all participants: $r=-0.075$, $p=0.69$; male participants: $r=-0.062$, $p=0.82$; female participants: $r=0.094$, $p=0.73$). B.M.I. was not used as a covariate in any analyses of appetite.

8.8.1.3. Dietary Restraint

High and low consumers were designed to be similar in Dietary Restraint. Significant differences however, were found between consumer groups in D.E.B.Q.-R. scores ($F(3,28)=7.75$, $p=0.001$). Female high consumers were significantly more restrained than female low consumers ($t(14)=-2.36$, $p=0.03$), male high consumers ($t(14)=-2.34$, $p=0.04$) and male low consumers ($t(14)=-4.70$, $p<0.001$). Male low consumers were significantly less restrained than female low consumers ($t(14)=-3.23$, $p=0.006$). No significant differences were found between male low and high consumers ($t(14)=-1.95$, $p=0.07$), or female low and male high consumers ($t(14)=-0.52$, $p=0.61$). No relationship was found between Dietary Restraint and total Test Meal Intake on Day 1 (all participants: $r=-0.233$, $p=0.20$; male participants: $r=-0.017$, $p=0.95$; female participants: $r=0.272$, $p=0.31$).

Due to the differences found between groups and the potential influence on appetite of dietary restraint, D.E.B.Q.-R. score was used as a covariate in all analyses on all participants and on female participants. D.E.B.Q.-R. score was not used in any analyses on male participants. The significance of the covariate in all analyses in which it was used, are shown following all analyses in Appendix 8.24 - 8.25.

8.8.2. SUBJECTIVE MEASURES OF APPETITE

8.8.2.1. All Participants

In the subjective measures of appetite, no significant differences were found between genders (smallest $F(1,27)=3.29$, $p=0.08$) or consumers (largest $F(1,27)=0.79$, $p=0.38$). Significant differences were found between preloads in scales of thirst ($F(2,56)=3.52$, $p=0.004$) and desire to drink ($F(2,56)=3.22$, $p=0.05$). All participants reported higher levels of thirst following NS compared to W in thirst ($F(1,28)=7.39$, $p=0.01$) and desire to drink ($F(1,28)=8.41$, $p=0.01$). No differences were found between NS and AS (thirst $F(1,28)=0.36$, $p=0.56$; desire to drink $F(1,28)=1.22$, $p=0.28$) or between AS and W (thirst $F(1,28)=3.22$, $p=0.08$; desire to drink $F(1,28)=1.97$, $p=0.17$). No significant differences between preloads were found in any of the scales of hunger (largest $F(2,56)=2.11$, $p=0.13$). Consistent significant effects of time were found (smallest $F(13,364)=7.77$, $p<0.001$). No significant 2-way interactions were found (largest $F(2,56)=2.27$, $p=0.11$). Analyses for multi-way interactions were not conducted. Temporal profiles of all thirst scales of subjective measures of appetite (preload by time), are displayed in Appendices 8.15-8.16.

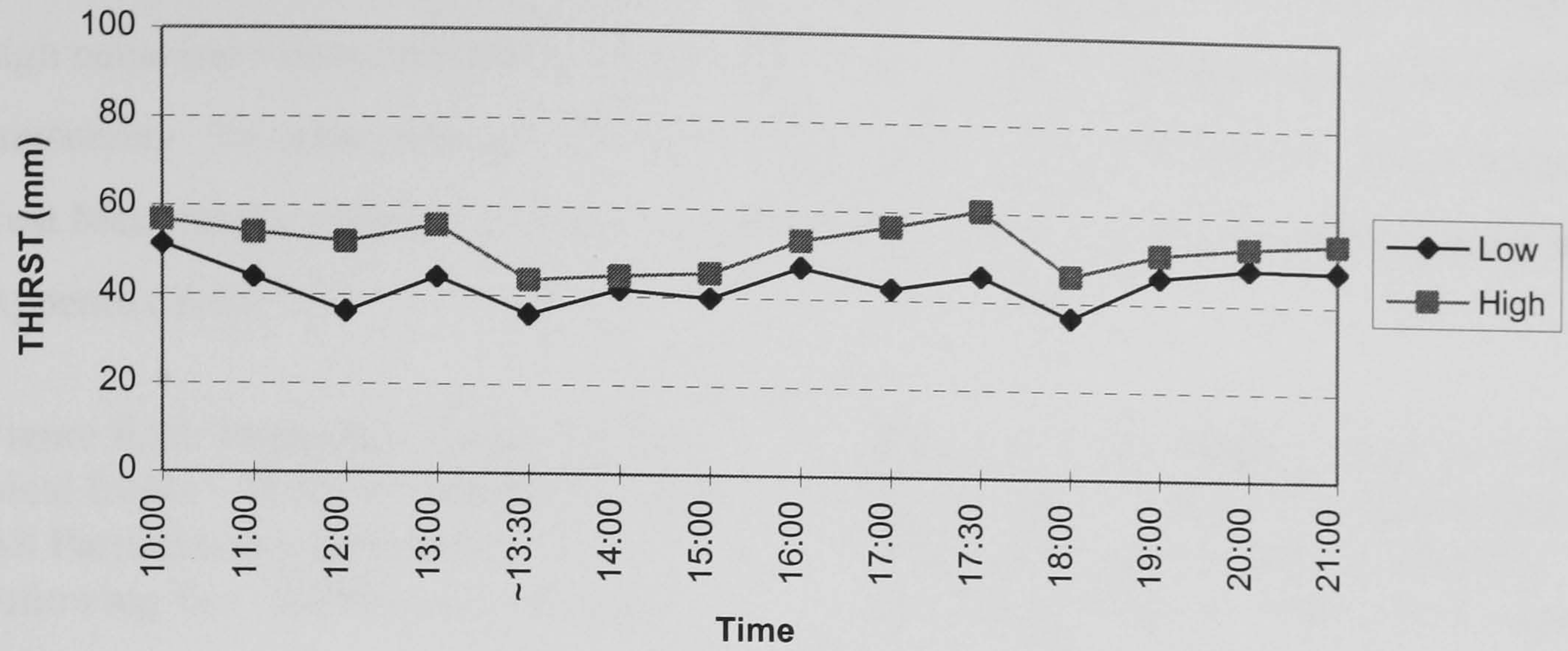
8.8.2.2. Male Participants

In all scales of subjective measures of appetite, no significant differences were found between consumers (largest $F(1,14)=0.79$, $p=0.39$) or preloads (largest $F(2,28)=1.89$, $p=0.17$). Significant effects of time were found (smallest $F(6,84)=4.04$, $p=0.001$). No systematic significant interactions were found. Analyses for multi-way interactions were not conducted.

8.8.2.3. Female Participants

In all scales of subjective measures of appetite, significant differences were found between consumers in scales of Thirst ($F(1,13)=4.48$, $p=0.05$) (see Figure 8.18 overleaf) and Desire to Drink ($F(1,13)=4.82$, $p=0.05$). Female high consumers reported higher levels of thirst than low consumers. No systematic significant differences were found between preloads. Significant effects of time were found (smallest $F(6, 84)=4.40$, $p=0.01$). No significant 2-way interactions were found (largest $F(2,28)=1.56$, $p=0.23$). Analyses for multi-way interactions were not conducted.

Figure 8.18: Temporal Profile for Subjective Measures of Thirst - Female Participants - Consumer by Time



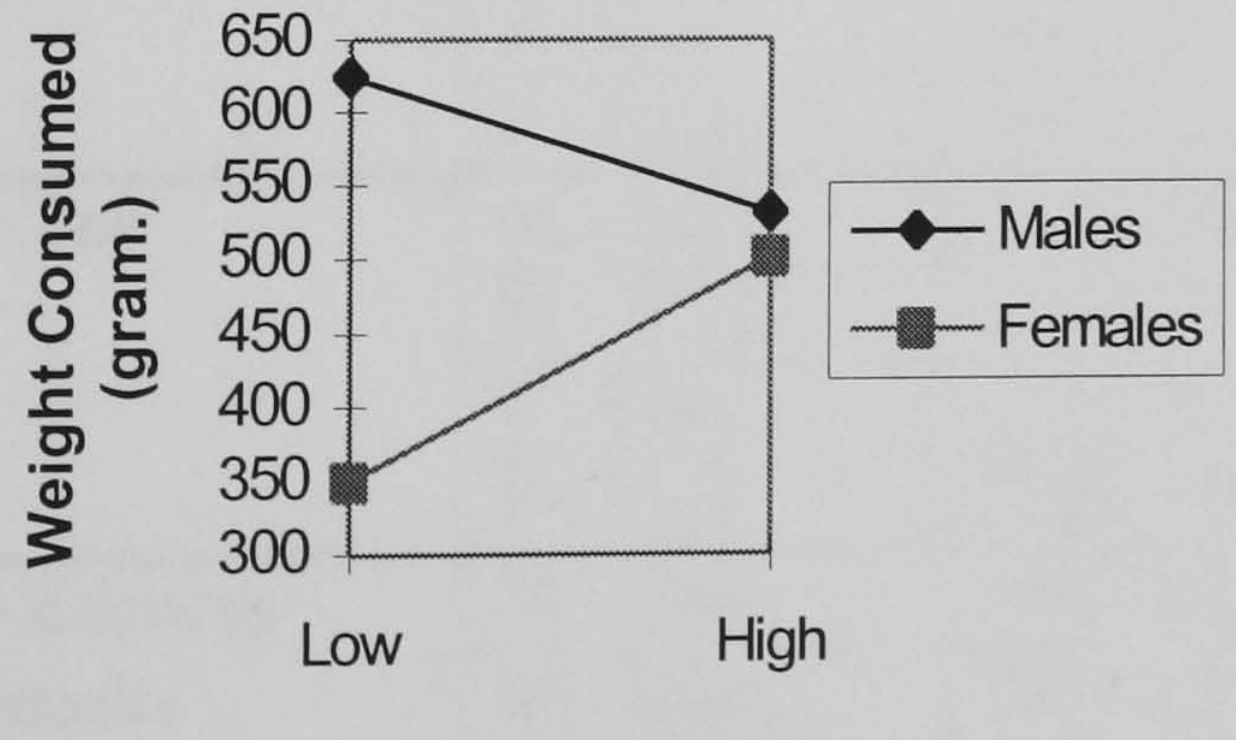
8.8.3. BEHAVIOURAL MEASURES OF APPETITE

8.8.3.1. All Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual Test Meal Intake, one significant difference was found between genders in lunch intake (F(1,27)=5.84, p=0.02). Males consumed more weight of food than females. No significant differences were found between consumers (largest F(1,27)=0.31, p=0.58) or preloads (largest F(1,27)=2.36, p=0.10). One significant interaction was found between gender and consumer in lunch intake (F(2,56)=4.69, p=0.04) (see Figure 8.19). In male participants - high consumers consumed a <u>similar</u> weight of food as low consumers (t(14)=1.02, p=0.33); in female participants - high consumers consumed significantly <u>more</u> weight of food than low consumers (t(14)=2.38, p=0.03). No other systematic interactions were found. Individual Test Meal Intake - Weight Consumed is shown in Appendix 8.17.

Figure 8.19: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - All participants - Lunch Intake - Gender by Consumer



In Cumulative Test Meal Intake, consistent significant differences were found between genders (smallest F(1,27)=5.29, p=0.03). Males consumed a greater weight of food than females. No significant differences were found between consumers (largest F(1,26)=0.19, p=0.66) or preloads (largest F(2,54)=2.52, p=0.09). Significant interactions were found between gender and consumer following tea (F(1,27)=4.16, p=0.05) and at the end of

Day 1 (F(1,27)=4.96, p=0.03) (see Figures 8.20 and 8.21). In male participants - high consumers consumed a similar weight of food as low consumers; in female participants - high consumers demonstrated a trend toward consumption of more weight of food than low consumers. No other interactions were found (largest F(1,27)=2.98, p=0.10). Cumulative Test Meal Intake - Weight Consumed is shown in Table 8.7 and is shown (with analysis) in Appendix 8.18.

Figure 8.20: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - All Participants - Cumulative Intake following Tea - Gender by Consumer

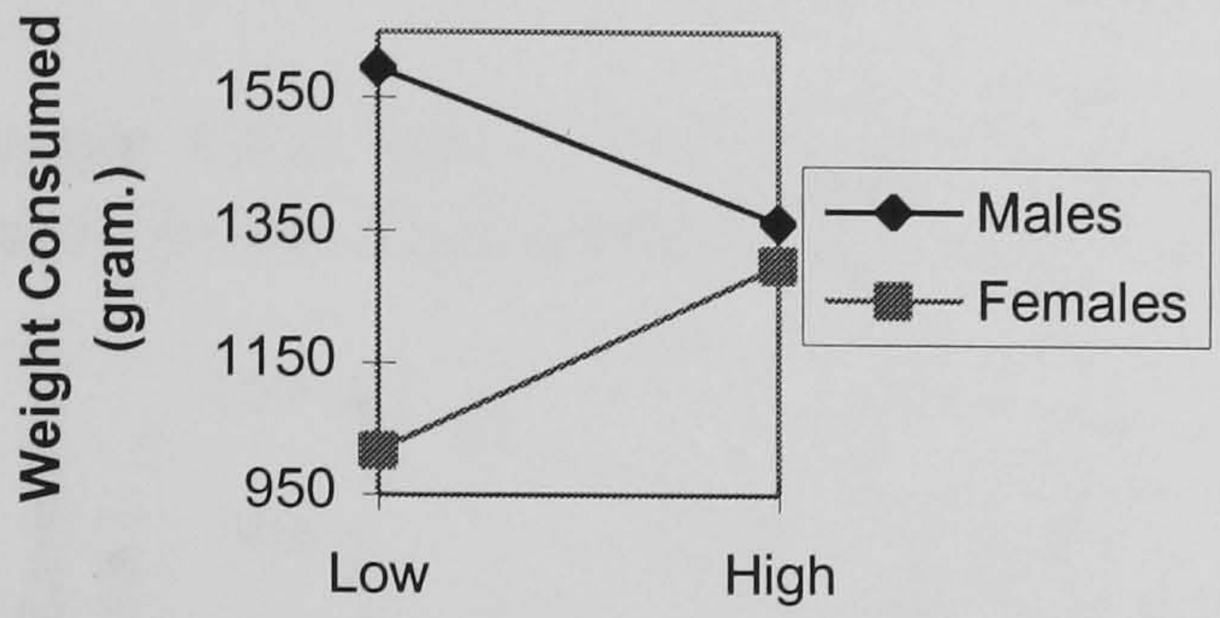


Figure 8.21: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - All Participants - Cumulative Intake at the end of Day 1 - Gender by Consumer

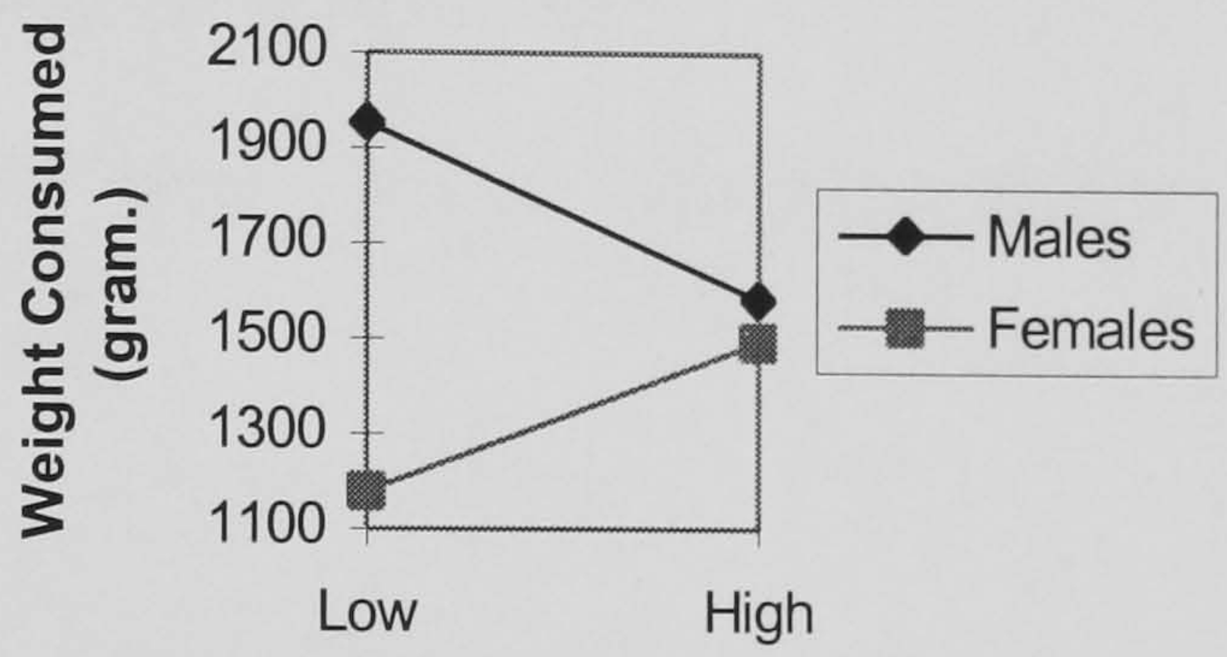


Table 8.7: Cumulative Test Meal Intake - Weight Consumed (gram.) (mean (st.dev.))

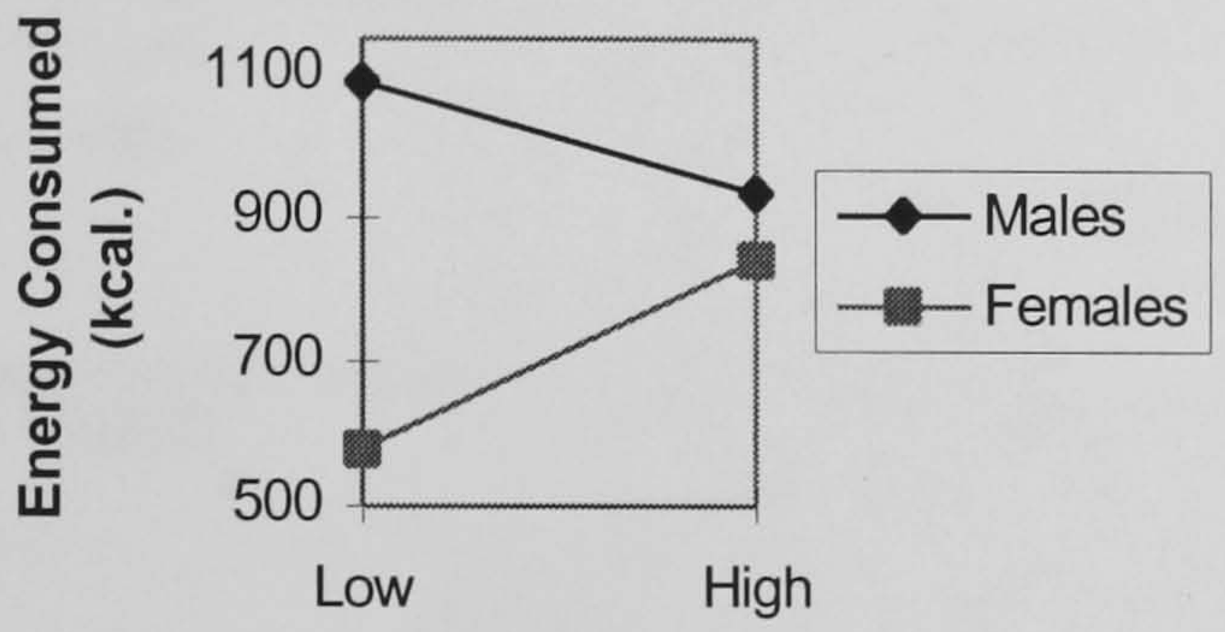
Meal	Consumer	Condition		
		W	AS	NS
Morning Snacks	M - Low	105 (106)	128 (136)	131 (146)
	M - High	67 (81)	127 (102)	75 (43)
	F - Low	104 (182)	33 (36)	61 (93)
	F - High	47 (31)	31 (23)	15 (28)
+ Lunch	M - Low	689 (251)	765 (360)	781 (339)
	M - High	610 (162)	681 (236)	572 (116)
	F - Low	463 (184)	405 (135)	376 (132)
	F - High	525 (186)	586 (164)	485 (192)
+ Afternoon Snacks	M - Low	775 (298)	836 (426)	886 (400)
	M - High	681 (206)	734 (255)	631 (140)
	F - Low	492 (185)	440 (141)	383 (135)
	F - High	566 (167)	619 (154)	515 (183)
+ Tea	M - Low	1576 (387)	1553 (678)	1657 (501)
	M - High	1400 (200)	1432 (339)	1253 (150)
	F - Low	1076 (324)	1051 (251)	922 (290)
	F - High	1281 (378)	1362 (377)	1251 (390)
+ Evening Snacks	M - Low	1944 (507)	1934 (732)	1982 (677)
	M - High	1657 (263)	1676 (479)	1415 (147)
	F - Low	1206 (379)	1257 (347)	1068 (326)
	F - High	1459 (395)	1548 (509)	1470 (474)
+ Day 2	M - Low	3280 (602)	3319 (671)	3325 (739)
	M - High	2868 (417)	2807 (524)	2770 (540)
	F - Low	2340 (618)	2433 (540)	2194 (722)
	F - High	2410 (602)	2955 (1075)	2481 (772)

Consumer: M = Male, F = Female; Low = Low Consumer of Artificially-Sweetened Beverages,
High = High Consumer of Artificially-Sweetened Beverages

Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, significant differences were found between genders in morning snack intake (F(1,27)=6.08, p=0.02), in lunch intake (F(1,27)=12.18, p=0.002) and in following day intake (F(1,26)=6.44, p=0.02). Males consumed more energy than females. No significant differences were found between consumers (largest F(1,27)=0.21, p=0.65) or between preloads (largest F(2,56)=2.31, p=0.11). One significant interaction was found between gender and consumer in lunch intake (F(2,56)=3.51, p=0.04) (see Figure 8.22). In male participants - high consumers consumed a similar amount of energy as low consumers (t(14)=1.19, p=0.26); in female participants - high consumers consumed significantly more energy than low consumers (t(14)=-2.54, p=0.02).

Figure 8.22: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - All Participants - Lunch Intake - Gender by Consumer



A significant consumer by preload interaction was found in morning snack intake (F(2,28)=3.54, p=0.04) (see Figure 8.23). Low consumers consumed a similar amount of energy following AS and NS (t(15)=-0.51, p=0.61). High consumers consumed significantly less energy following NS than AS (t(15)=2.51, p=0.02). No other interactions were found. Individual Test Meal Intake - Energy Consumed is shown in Appendix 8.19.

In Cumulative Test Meal Intake, consistent significant differences were found between genders (smallest F(1,27)=8.94, p=0.006). Males consumed more energy than females. No significant differences were found between consumers (largest F(1,27)=0.09, p=0.77). One significant difference was found between preloads following lunch (largest F(2,56)=3.40, p=0.04). Participants consumed significantly less following NS than AS (t(14)=2.17, p=0.04). No differences were found between NS and W (t(14)=-0.42, p=0.68), or W and AS (t(14)=1.90, p=0.07). A significant consumer by preload interaction was found following lunch (F(2,56)=3.07, p=0.05) (see Figure 8.24). Low consumers consumed a similar amount of energy following AS and NS (t(15)=-0.04, p=0.97); high consumers consumed significantly less energy following NS than AS (t(15)=2.66, p=0.02). No other significant interactions were found. Cumulative Test Meal Intake - Energy Consumed is shown in Table 8.8 and is shown (with analysis) in Appendix 8.20.

Figure 8.23: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - All Participants - Morning Snack Intake - Consumer by Preload

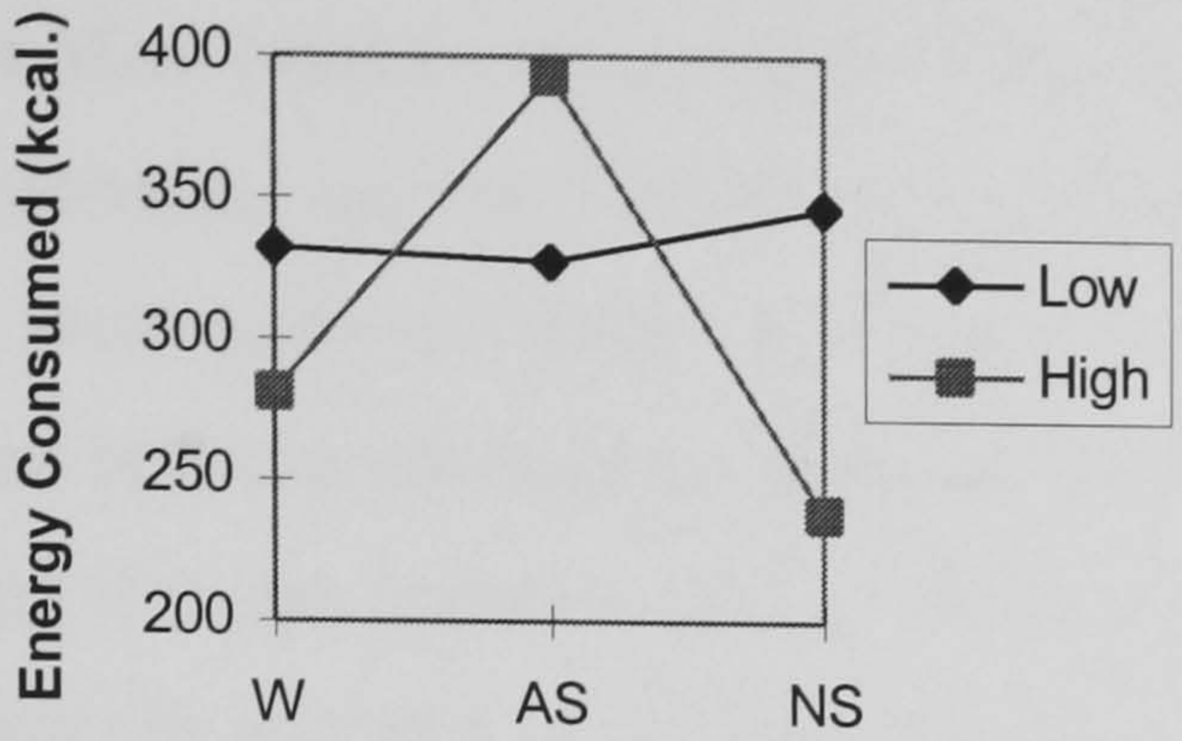


Figure 8.24: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - All Participants - Cumulative Intake following Lunch - Consumer by Preload

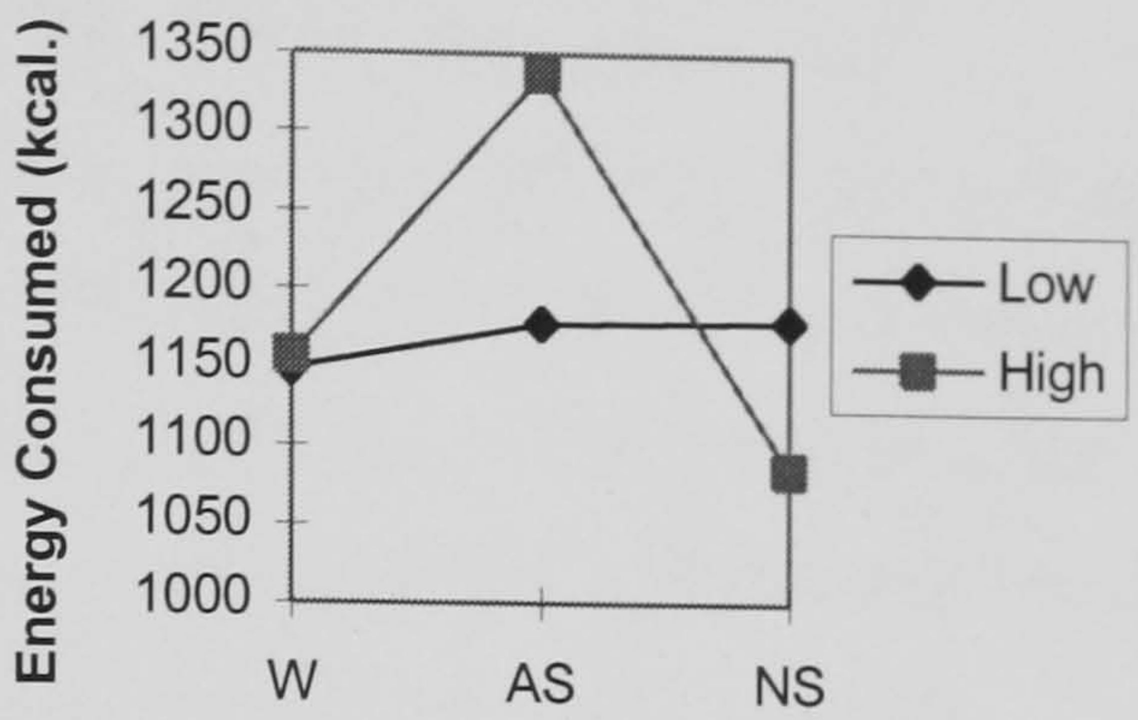


Table 8.8: Cumulative Test Meal Intake - Energy Consumed (kcal.) (mean (st.dev.))

Meals	Consumer	Condition		
		W	AS	NS
Morning Snacks	M - Low	551 (555)	485 (511)	504 (533)
	M - High	310 (336)	645 (414)	396 (164)
	F - Low	113 (111)	169 (183)	188 (169)
	F - High	252 (141)	140 (131)	80 (147)
+ Lunch	M - Low	1593 (735)	1584 (790)	1630 (783)
	M - High	1267 (411)	1597 (628)	1294 (334)
	F - Low	704 (169)	772 (276)	730 (216)
	F - High	1046 (290)	1077 (327)	876 (317)
+ Afternoon Snacks	M - Low	2044 (1133)	1958 (1263)	2179 (1254)
	M - High	1639 (683)	1872 (728)	1602 (466)
	F - Low	850 (253)	954 (331)	768 (241)
	F - High	1262 (272)	1255 (316)	1033 (287)
+ Tea	M - Low	2889 (1144)	2724 (1290)	3022 (1405)
	M - High	2387 (622)	2676 (805)	2336 (533)
	F - Low	1471 (357)	1628 (387)	1348 (423)
	F - High	1997 (420)	1985 (345)	1767 (426)
+ Evening Snacks	M - Low	3922 (1703)	3787 (1860)	3974 (1938)
	M - High	3068 (959)	3348 (1129)	2978 (734)
	F - Low	1826 (471)	2121 (611)	1728 (431)
	F - High	2603 (509)	2662 (629)	2421 (675)
+ Day 2	M - Low	6245 (1713)	6325 (1917)	6569 (2607)
	M - High	5714 (1983)	5813 (1869)	5498 (1470)
	F - Low	3828 (762)	3836 (760)	3452 (671)
	F - High	4211 (746)	4756 (849)	3946 (770)

Consumer: M = Male, F = Female; Low = Low Consumer of Artificially-Sweetened Beverages, High = High Consumer of Artificially-Sweetened Beverages

Total Energy Intake (kcal.):

In Cumulative Total Energy Intake, effects of gender and consumer remained as in test meal intake - energy consumed. Consistent significant differences were also found between preloads on Day 1 (smallest $F(2,56)=8.45$, $p=0.001$). Participants consumed significantly more energy on the days they received NS than on the days they received AS (smallest t(31)=-2.00, p=0.05) and than on the days they received W (smallest t(31)=4.10, p<0.001). No differences were found between W and AS (largest t(31)=2.08, p=0.06). No systematic interactions were found. Cumulative Total Energy Intake is shown in Appendix 8.21.

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no systematic differences were found between genders. No differences were found between consumers (largest F(1,26)=3.86, p=0.06). No systematic differences were found between preloads, and no systematic interactions were found. Individual Test Meal Intake - Proportions of All Macronutrients Consumed is shown in Appendix 8.22.

In cumulative test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no significant differences were found between genders (largest F(1,26)=2.04, p=0.17), consumers (largest F(1,26)=2.36, p=0.14), or preloads (largest F(2,24)=3.21, p=0.06). No systematic interactions were found. Cumulative Test Meal Intake - Proportions of All Macronutrients Consumed is shown in Appendix 8.23.

Summary:

All systematic significant results in all participants in the behavioural measures of appetite are summarized in Table 8.9.

Table 8.9: All Systematic Significant Results in the Behavioural Measures of Appetite - All Participants (including meals where significant results were found).

	Gender	Cons	Gender by Consumer	Preload	Consumer by Preload #
Test Meal Intake -Weight Consumed (gram.)					
Individual	M > F (lunch)		M: LC = HC F: LC < HC (lunch)		
Cumulative	**M > F (all)**		M: LC = HC F: LC < HC (tea, day 1)		
Test Meal Intake -Energy Consumed (kcal.)					
Individual	M > F (morn, lun, day 2)		M: LC = HC F: LC < HC (lunch)		LC: W = AS = NS HC: W = AS > NS (morn)
Cumulative	**M > F (all)**			AS > NS (AS = W = NS) (lunch)	LC: W = AS = NS HC: W = AS > NS (lunch)
Total Energy Intake (kcal.)					
Cumulative	As Above			**W = AS < NS (all)**	
Test Meal Intake -Approximate Proportions of All Macronutients Consumed (%kcal.)					
Individual					
Cumulative					

Effects of Gender: M = Male Participants, F = Female Participants,
Effects of Consumer: LC = Low Consumers, HC = High Consumers,
Effects of Preload: W = Water, AS = Artificially Sweetened Drink, NS = Naturally Sweetened Drink.
No systematic significant Gender by Preload interactions or Gender by Consumer by Preload interactions were found.

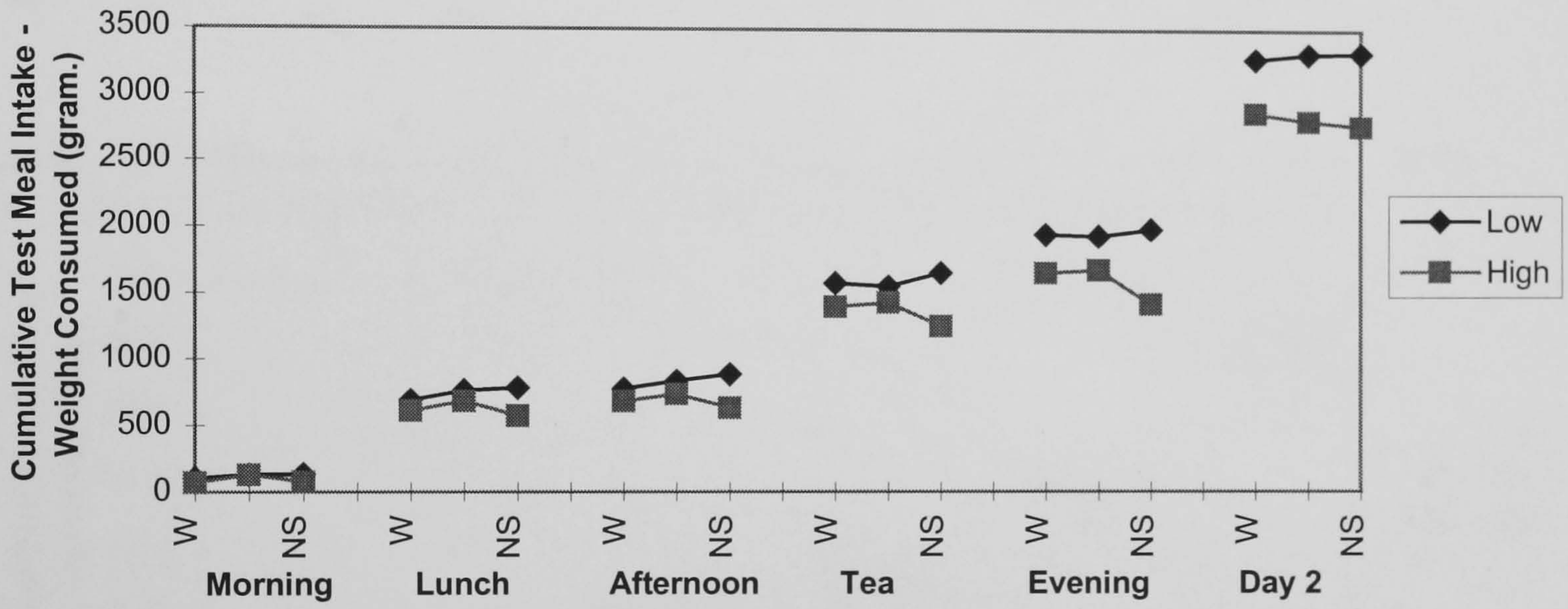
8.8.3.2. Male Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=2.40$, $p=0.14$) or preloads (largest $F(2,26)=2.00$, $p=0.16$). No significant interactions were found (largest $F(2,26)=2.02$, $p=0.15$).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=3.39$, $p=0.09$) or preloads (largest $F(2,28)=1.99$, $p=0.16$). No significant interactions were found (largest $F(2,28)=2.76$, $p=0.08$). The consistency of effects can be seen in Figure 8.25.

Figure 8.25: Diagram of Cumulative Test Meal Intake - Weight Consumed (gram.) - Male Participants. Line Graphs allow clear comparisons between consumers and preloads



Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=1.82$, $p=0.20$). No systematic differences were found between preloads. One significant interaction was found (consumer by preload) in morning snack intake ($F(2,26)=7.01$, $p=0.003$) (see Figure 8.26). Low consumers consumed a <u>similar</u> amount of energy following W and AS ($t(14)=-1.02$, $p=0.34$), high consumers consumed <u>more</u> energy following AS than following W ($t(14)=3.74$, $p=0.01$). Low consumers consumed a <u>similar</u> amount of energy following AS and NS ($t(14)=-0.53$, $p=0.61$), high consumers consumed <u>more</u> energy following AS than following NS ($t(14)=2.36$, $p=0.05$).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,14)=1.15$, $p=0.30$) or preloads (largest $F(2,28)=2.36$, $p=0.11$). One significant interaction was found (consumer by preload) following tea ($F(2,28)=3.50$, $p=0.04$) (see Figure 8.27). Low consumers consumed <u>similar</u> amounts of energy following W and AS ($t(7)=-0.95$, $p=0.37$) and AS and NS ($t(7)=-1.98$, $p=0.09$); high consumers demonstrated a trend toward consumption of more energy following AS compared to W and NS (smallest t(7)=1.76, p=0.12). The consistency of all effects can be seen in Figure 8.28.

Figure 8.26: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - Morning Snacks Intake - Consumer by Preload

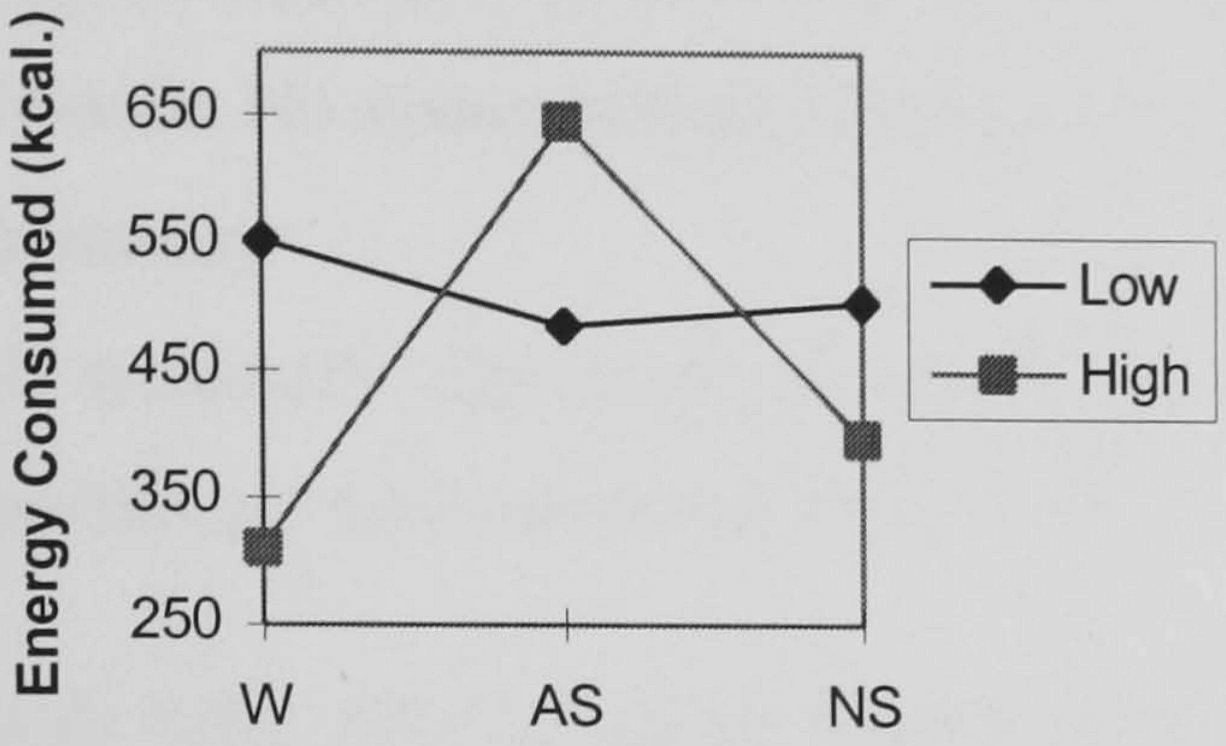


Figure 8.27: Interaction Graph for Test Meal Intake - Energy Consumed (kcal.) - Cumulative Intake following Lunch - Consumer by Preload

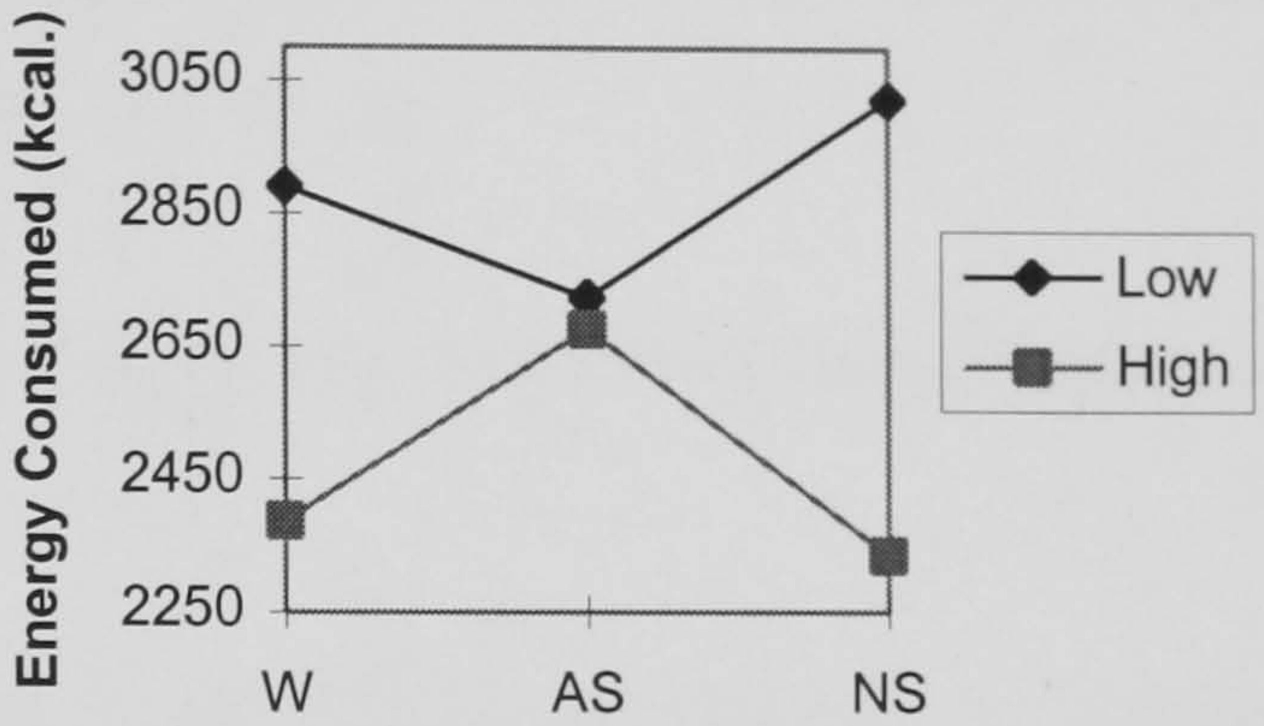
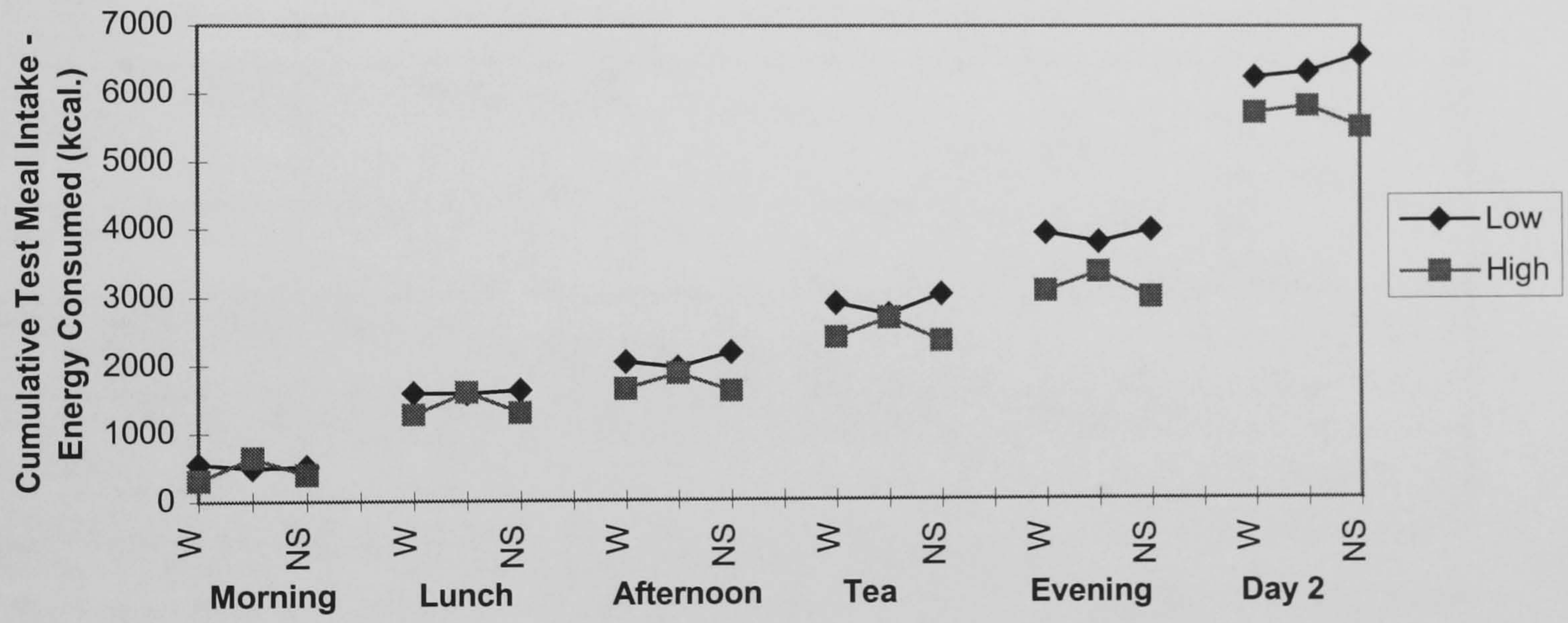


Figure 8.28: Diagram of Cumulative Test Meal Intake - Energy Consumed (kcal.) - Male Participants. Line Graphs allow clear comparisons between consumers and preloads



Total Energy Intake (kcal.):

In Cumulative Total Energy Intake, effects of consumer remained as in test meal intake - energy consumed. Consistent significant differences were found between preloads on Day 1 (smallest F(2,28)=6.38, p=0.005). Male participants consumed more total energy on the days they received NS than on the days they received AS (smallest t(15)=-1.25, p=0.23) and than on the days they received W (smallest t(14)=3.26, p=0.005). No significant differences were found between W and AS (largest t(15)=1.85, p=0.08). No significant interactions were found (largest F(2,28)=3.20, p=0.06).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no systematic significant differences were found between consumers or preloads. No significant interactions were found (largest F(1,15)=3.22, p=0.06).

In cumulative test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no significant differences were found between consumers (largest F(1,15)=3.68, p=0.08). No systematic significant differences were found between preloads. No systematic significant interactions were found.

Summary:

All systematic significant results in male participants only in the behavioural measures of appetite are summarized in Table 8.10.

Table 8.10: All Systematic Significant Results in the Behavioural Measures of Appetite - Male Participants (including meals where significant differences were found).

	Consumer	Preload	Consumer x Preload
Test Meal Intake -Weight Consumed (gram.)			
Individual			
Cumulative			
Test Meal Intake -Energy Consumed (kcal.)			
Individual			LC: W = AS = NS HC: W < AS > NS (morn)
Cumulative			LC: W = AS = NS HC: W < AS > NS (tea)
Total Energy Intake (kcal.)			
Cumulative		**W = AS < NS (all)**	
Test Meal Intake -Approximate Proportions of All Macronutients Consumed (%kcal.)			
Individual			
Cumulative			

Effects of Consumer: LC = Low Consumers, HC = High Consumers,
Effects of Preload: W = Water, AS = Artificially Sweetened Drink, NS = Naturally Sweetened Drink.

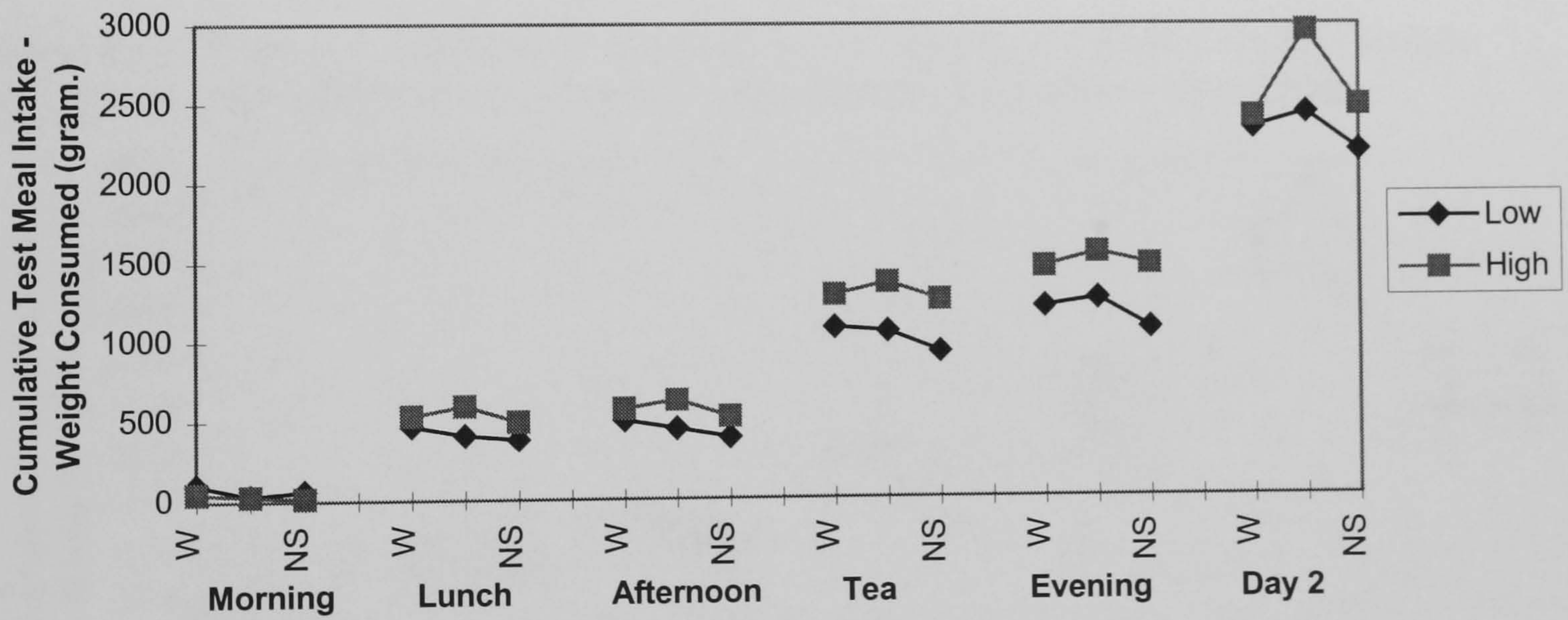
8.8.3.3. Female Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual Test Meal Intake, one significant difference was found between consumers in lunch intake ($F(1,13)=6.56$, $p=0.03$). High consumers consumed more weight of food than low consumers. One significant difference was found between preloads on the following day ($F(2,28)=3.62$, $p=0.04$). Female participants consumed significantly more weight of food following AS than following W ($t(15)=2.13$, $p=0.05$). No differences were found between AS and NS ($t(15)=1.97$, $p=0.07$), or W and NS ($t(15)=0.28$, $p=0.98$). No significant interactions were found (largest $F(2,28)=2.41$, $p=0.11$).

In Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(1,13)=3.19$, $p=0.60$). One significant difference was found between preloads at the end of Day 2 ($F(2,28)=5.37$, $p=0.01$). Female participants consumed significantly more weight of food following AS than following NS ($t(15)=3.54$, $p=0.003$). No differences were found between AS and W ($t(15)=2.08$, $p=0.06$), or between W and NS ($t(15)=-0.35$, $p=0.73$). No significant interactions were found (largest $F(1,13)=1.78$, $p=0.19$). The consistency of effects can be seen in Figure 8.29.

Figure 8.29: Diagram of Cumulative Test Meal Intake - Weight Consumed (gram.) - Female Participants. Line Graphs allow clear comparisons between consumers and preloads

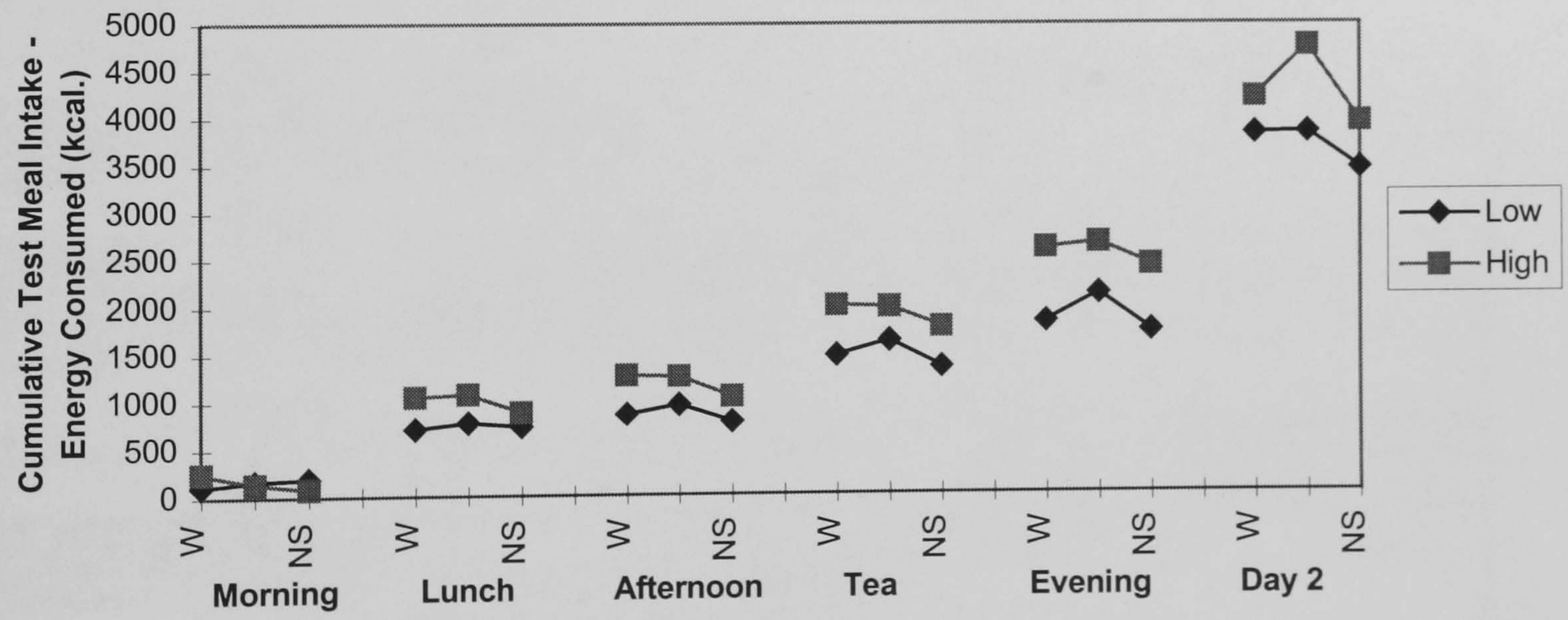


Test Meal Intake - Energy Consumed (kcal.):

In Individual Test Meal Intake, one significant difference was found between consumers in lunch intake ($F(1,13)=6.80$, $p=0.02$). High consumers consumed more energy than low consumers. One significant difference was found between preloads in following day intake ($F(2,28)=3.31$, $p=0.05$). Participants consumed significantly less following NS than following W ($t(15)=-2.15$, $p=0.04$) and demonstrated a similar trend following AS (t(15)=2.00, p=0.06). No differences were found between W and AS (t(15)=0.64, p=0.53). No systematic interactions were found.

In Cumulative Test Meal Intake, consistent significant differences were found between consumers (smallest F(1,13)=5.87, p=0.03). High consumers consumed more energy than low consumers. Significant differences were found between preloads following afternoon snacks (F(2,28)=3.39, p=0.05), following tea (F(2,28)=3.50, p=0.04) and following Day 2 (F(2,28)=4.75, p=0.02). On Day 1 (following afternoon snacks and following tea), participants consumed less following NS than following AS (smallest t(31)=2.47, p=0.03), and demonstrated a similar trend following W (largest t(31)=-2.00, p=0.06). No differences were found between AS and W (largest t(31)=0.84, p=0.42). Following Day 2, participants consumed significantly less following NS than following W (t(30)=2.23, p=0.04) and demonstrated a similar trend following AS (t(30)=2.00, p=0.06). No differences were found between AS and W (t(30)=0.64, p=0.53). No significant interactions were found (largest F(2,28)=1.22, p=0.31). Systematic trends however can be seen (Figure 8.30). Low consumers consumed more energy following AS and less energy following NS, compared to W. High consumers consumed less energy following NS compared to W, no differences are seen between W and AS. The consistency of effects can be seen in Figure 8.30.

Figure 8.30: Diagram of Cumulative Test Meal Intake - Energy Consumed (kcal.) - Female Participants. Line Graphs allow clear comparisons between consumers and preloads



Total Energy Intake (kcal.):

In Cumulative Total Energy Intake, effects of consumer remained as in test meal intake - energy consumed. Significant differences were also found between preloads following lunch (F(2,28)=3.69, p=0.04) and following tea (F(2,28)=5.91, p=0.01). Following lunch, female participants consumed more total energy on the days they received NS than on the days they received W (t(15)=2.80, p=0.01). No significant differences were found between NS and AS (t(15)=-1.57, p=0.14) or between AS and W (t(15)=0.97, p=0.35). Following tea, female participants consumed more total energy on the days they received NS than on the days they received W (t(15)=3.18, p=0.006) and than on they received AS (t(15)=-2.42. p=0.03). No significant differences were found between W and AS (t(15)=1.07, p=0.30). No significant interactions were found (largest F(2,28)=1.22, p=0.31).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In individual test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no systematic significant differences were found between consumers. No significant differences were found between preloads (largest F(2,28)=1.25, p=0.30). No interactions were found (largest F(2,28)=2.21, p=0.11).

In cumulative test meal intake, in proportions of energy consumed from carbohydrate, fat and protein, no significant differences were found between consumers (largest F(1,15)=3.55, p=0.08) or preloads (largest F(2,28)=1.77, p=0.19). No systematic significant interactions were found.

Summary:

All systematic significant results in female participants only in the behavioural measures of appetite are summarized in Table 8.11.

Table 8.11: All Systematic Significant Results in the Behavioural Measures of Appetite - Female Participants (including meals where significant differences were found).

	Cons	Preload	Consumer x Preload
Test Meal Intake -Weight Consumed (gram.)			
Individual	LC < HC (lunch)	W < AS = NS (W = NS) (day 2)	
Cumulative		W < AS = NS (W = NS) (day 2)	
Test Meal Intake -Energy Consumed (kcal.)			
Individual	LC < HC (lunch)	W = AS > NS (day 2)	
Cumulative	**LC < HC (all)**	W = AS > NS (aft'n, tea, day 2)	LC: W < AS > NS (all on day 1) HC: W = AS > NS (n.s. trend)
Total Energy Intake (kcal.)			
Cumulative	As Above	W < NS (W = AS = NS) (lunch) W = AS < NS (tea)	
Test Meal Intake -Approximate Proportions of All Macronutients Consumed (%kcal.)			
Individual			
Cumulative			

Effects of Consumer: LC = Low Consumers, HC = High Consumers,
Effects of Preload: W = Water, AS = Artificially Sweetened Drink, NS = Naturally Sweetened Drink.

8.9. DISCUSSION

On analysing all participants together, significant differences were found in this study, between genders, consumers and preloads. Differences between consumers and preloads differed between genders. Differences between consumers and preloads will only be considered in males and females separately. The majority of findings in all participants together can be attributed to the male participants.

8.9.1. FEMALE PARTICIPANTS

In female participants, the main findings of this study are:

- High consumers of artificially-sweetened beverages consumed significantly <u>more</u> in test meal intake (weight of food, energy) than low consumers.
- High consumers of artificially-sweetened beverages reported significantly <u>higher</u> levels of thirst in the subjective measures, than low consumers.
- Participants consumed significantly <u>more</u> in test meal intake (weight of food) following the AS preload than following the W preload.
- Participants consumed significantly <u>more</u> in test meal intake (weight of food, energy) following the AS preload than following the NS preload.
- Low consumers of artificially-sweetened beverages demonstrated responses to sweetness and energy, high consumers of artificially-sweetened beverages demonstrated responses to energy, but no responses to sweetness.

8.9.1.1. High and Low Consumers of Artificially-Sweetened Beverages

Differences between consumers are clearly demonstrated. High consumers of artificially-sweetened beverages consumed significantly more than low consumers. This effect can be explained as a result of the uncoupling of sweetness and energy, as a result of the high consumption of sweetness, the high consumption of artificially-sweetened beverages, or as a result of associations with the self-selection of a high consumption of artificial sweeteners, as discussed in Chapter 3.

Considering the uncoupling of sweetness and energy, the habitual uncoupling of sweetness and energy may realistically result either in no change in the sweetness-energy relationship, or an extinction of the sweetness-energy relationship. If the relationship remains unchanged, the habitual consumption of sweetness without energy will result in the habitual experience of an increased appetite. These results thus, may be considered to suggest that the habitual consumption of sweetness without energy has no effect on the sweetness-energy relationship: the sweetness-energy relationship persists and results in increases in appetite.

Considering the habitual consumption of sweetness, high consumers of artificially-sweetened beverages are consuming high levels of sweetness. As a result of this repeated exposure, the taste of sweetness may be habituated to (Frijters, 1987), i.e. - the experience of sweetness may become diminished. The diminished experience of a repetitive stimulus is well-known (e.g. Klein, 1996; Gleitman, 1991). A habituation to sweetness may result in increases in appetite for and an increase in consumption of sweetness. A habituation to sweetness however has not been found previously either in the short-term (e.g. Schifferstein and Frijters, 1992), or in the long term in high consumers of sweetened beverages (Tepper, Hartfiel and Schneider, 1996). Furthermore, if habituation is considered to occur, a diminished response to sweetness in the high consumers would only explain an increase in consumption of sweet foods (Klein, 1996). A habituation to sweetness could not explain an increased appetite for all foods. The specific consumption of sweet and non-sweet foods however was not measured in this study.

Considering the high consumption of artificially-sweetened beverages, high consumers of artificially-sweetened beverages are also consuming high levels of weak solutions. Due to osmotic imbalances, high levels of consumption of hypotonic solutions can result also in high levels of consumption of solid foods (Tordoff, 1988a; 1988b). The normal high consumption of fluids by the high consumers may result in a normal high consumption of food. This explanation however does assume all artificially-sweetened beverages to be hypotonic, and may be completely invalid if low consumers are consuming similar quantities of water - another hypotonic solution (Tordoff, 1988b). Increases in food consumption in response to the high consumption of hypotonic solutions have also to date only been demonstrated in animals. Effects in humans are yet to be shown (Tordoff, 1988b)

Considering associations with the deliberate self-selection of artificial sweeteners, differences between consumers may also be explained by differences in levels of physical activity. Physical activity is frequently employed to aid weight control and may be highly correlated with other aids to weight control, such as the consumption of artificially-sweetened beverages (e.g. McGuire, Wing, Klem, Seagle and Hill, 1998; Schoeller, Shay and Kushner, 1997). High levels of physical activity may result in high levels of appetite (e.g. King and Blundell, 1995).

Consumer groups may also differ in disinhibition. Disinhibition refers to a propensity towards uninhibited over-eating once normal restraints on eating are relaxed. Disinhibition is often highly correlated with dietary restraint, and has frequently been demonstrated in a variety of situations where normal restraints on eating are relaxed (Laessle, Tuschl, Kotthaus and Pirke, 1989; Stunkard and Messick, 1985). The increased consumption by the high consumers in this study may be a demonstration of greater disinhibition in the high consumers when eating under observation in an artificial laboratory situation. Disinhibition was not measured in this study however, and high correlations between restraint and disinhibition are not always found (e.g. Westerterp-Plantenga, Kempen and Saris, 1998; Stunkard and Messick, 1985). Differences between consumer groups however, were not due to B.M.I. or Dietary Restraint.

Significant differences between high and low consumers of artificially-sweetened beverages were also found in this study in the subjective measures of thirst. Female high consumers reported higher levels of thirst than low consumers. This effect is surprising. Water was freely supplied in excess during all meals and all participants were free to consume as much water as they wished throughout the day. Increases in thirst in the high consumers may thus be indicative not of increases in thirst but of an unwillingness to satisfy that thirst with water, or may be indicative of nothing more than differences between consumers in habitual fluid consumption levels or differences in extreme measures of thirst (V.A.S. anchors on which to rate levels of thirst) (see Hill, Blundell and Rogers, 1995). High levels of thirst in the high consumers throughout the day are also worthy of comment considering the high levels of intake in the high consumers. High levels of thirst are typically associated with a <u>decrease</u> in appetite (e.g. Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996). This may be further evidence for a reporting of higher levels of habitual fluid consumption as opposed to actual higher levels of thirst.

8.9.1.2. Effects on Appetite of Sweetness (W vs. AS) and Energy (AS vs. NS)

Effects were also found in this study, in all female participants, in response to sweetness (W vs. AS) and in response to energy (AS vs. NS). Compared to the non-sweet/low energy (W) preload, the sweet/low energy (AS) preload was found to increase subsequent appetite. This effect has been demonstrated previously in this thesis (Chapter 6) and in the wider field of recent research (see Chapter 2). The effect can be understood as a result of the reliable relationship between sweetness and energy. The increase in appetite however is small and did not always reach significance. A small size of effects have been previously suggested (Chapter 2), and may also have been masked slightly by a potential difference in appetite following the consumption of aspartame (see Chapter 2, section 2.2.4.1).

Compared to the sweet/low energy (AS) preload, the sweet/high energy (NS) preload was found to decrease subsequent appetite. This decrease in appetite in response to energy has also been previously demonstrated (Chapter 6, see Chapter 2), and can be attributed to the energy contained in the sweet/high energy preload. The decrease in appetite in response to energy in this study however, was small and did not always reach significance. Only small compensation in test meal intake for the energy consumed in the preload is also suggested by the significant increase in total energy consumed on the days participants received the sweet/high energy preload. This increase in total energy consumed however, decreased throughout Day 1 and was not significant at the end of Day 2. Compensation for the energy in the preload may have occurred gradually. Gradual compensation has previously been demonstrated (e.g. Lavin, French and Read, 1997).

The decrease in appetite following the sweet/high energy manipulation however, may also be related to the increased thirst and desire to drink following the sweet/high energy drink, demonstrated in the subjective measures of appetite. Increased thirst has previously been suggested to decrease hunger and food intake (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996). Effects on food intake in this study however are unlikely: increases in thirst and desire to drink following the NS preload were small, and only reached significance in the analysis of all participants; increases in thirst and desire to drink could be satisfied at any time throughout each study day, particularly at all meal times.

8.9.1.3. High and Low Consumers of Artificially-Sweetened Beverages in Responses to Sweetness (W vs. AS) and Energy (AS vs. NS)

Differences between consumers in response to sweetness and energy were also found in this study, though did not reach significance. In Figure 8.30, however, differences between consumers can be clearly seen. In the low consumers of artificially-sweetened beverages, responses to sweetness and responses to energy are clearly demonstrated. In the high consumers however, only responses to energy can be seen. There are no responses to sweetness. This difference between consumers can be explained as a result of the habitual uncoupling of sweetness and energy. As discussed in Chapter 3, the habitual uncoupling of sweetness and energy may result in the extinction of the sweetness-energy relationship. If the sweetness-energy relationship is extinguished, sweetness will no longer be indicative of subsequent energy, and will no longer affect appetite. Sweetness without energy will not affect appetite. Sweetness with energy will only affect appetite by virtue of the included energy. These effects are exactly those demonstrated in this study. These results thus, may be considered to suggest that the habitual consumption of sweetness without energy is associated with an extinction of the sweetness-energy relationship. (The results and explanation above are also not incompatible with the general increase in appetite found in the high consumers (section 8.9.1.1), in terms of explanation. A possible persistence and a possible extinction of the sweetness-energy relationship are discussed in more detail in the discussion of this thesis - Chapter 13).

The only other possible explanation for an absence of a response to sweetness in high consumers lies in the possibility that the effect found is a result of a habituation to sweetness (Frijters, 1987). As mentioned previously however, a habituation to sweetness in the short and the long term have previously not been found (Frijters and Schifferstein, 1992; Rolls, 1987; Tepper, Hartfiel and Schneider, 1996). An absence of a response to sweetness in high consumers as a result of a habituation also assumes low consumers of artificially-sweetened beverages are not consuming similar levels of sweetness in food items other than artificially-sweetened beverages. A habituation to sweetness in the high consumers however does remain a possibility. A habituation to sweetness in high consumers is investigated in this thesis in Study 6 (Chapter 10).

The small size and non-significance of effects can be understood as a result of the small size of the response to sweetness in the low consumers, particularly in comparison to the size of other effects found. The trend however is consistent and is easily observed.

Interestingly, a significant increase in appetite following the sweet/low energy (AS) preload manipulation was found in the high consumers on the following day. This delayed effect has been found before in regular consumers of sweetened drinks (Lavin, French and Read, 1997), but currently remains unexplained. Due to the delay however, this increase in appetite is unlikely to be a direct result of the sweetness/energy manipulations.

8.9.1.4. Summary

In sum, in female participants, differences were found between high and low consumers of artificially-sweetened beverages and between sweetness/energy manipulations. Compared to the low consumers, high consumers of artificially-sweetened beverages were found to consume significantly more, to report significantly higher levels of thirst, and to show different responses to sweetness. Low consumers demonstrated an increase in appetite in response to sweetness, high consumers did not. All participants responded similarly to energy with a decrease in subsequent appetite. Higher levels of consumption in the high consumers can be explained as a result of the uncoupling of sweetness and energy, as a demonstration of a sweetness-energy relationship that remains intact, but is often incorrect, or as a result of associations with the self-selected high consumption of artificial sweeteners as a result of high levels of the cognitive control of appetite. Higher levels of thirst are suggested to be a result of a high habitual fluid consumption. The absence of a response to sweetness is explained as a result of the habitual uncoupling of sweetness and energy as a demonstration of an extinction of the sweetness-energy relationship.

8.9.2. MALE PARTICIPANTS

In male participants, the main findings of this study are:

- High consumers of artificially-sweetened beverages consumed similar amounts in test meal intake (weight of food, energy) to low consumers.
- Participants consumed similar amounts in test meal intake (weight of food, energy) following the AS preload and following the W preload.
- Participants consumed similar amounts in test meal intake (weight of food, energy) following the AS preload and following the NS preload.
- High consumers of artificially-sweetened beverages demonstrated responses to sweetness and energy, low consumers of artificially-sweetened beverages demonstrated no responses to sweetness or energy.

8.9.2.1. High and Low Consumers of Artificially-Sweetened Beverages

In male participants, no overall differences were found between high and low consumers of artificially-sweetened beverages. A non-significant trend can be observed however, where low consumers of artificially-sweetened beverages consumed more than high consumers. This effect may be explained as a result of non-significant increases in dietary restraint in the high consumers (e.g. see de Castro, 1995)

8.9.2.2. Effects on Appetite of Sweetness (W vs. AS) and Energy (AS vs. NS)

No effects were found in male participants in this study, in response to sweetness (W vs. AS) or in response to energy (AS vs. NS). These findings are surprising. Effects of sweetness and energy were found in the female participants in this study and effects of sweetness and energy in male participants have previously been widely reported (see Chapter 2). The absence of effects of sweetness could, as in the last study, be explained by the reduced importance of taste in appetite in males (Zylan, 1996), but importance of taste can not explain the absence of effects of energy. The absence of effects of sweetness and energy may be explained by the size of the sweetness/energy manipulations. The effects on appetite of sweetness are reportedly small (Chapter 2). The effects on appetite of energy when provided in fluid form similarly have been suggested to be small (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996). In comparison, the levels of overall consumption in the male participants in this study are high (approx. 3500 kcal. on day 1). The small effects on appetite of sweetness and energy in fluid form, compared to the large effects on appetite of 3500 kcal. are unlikely to be noticed. Effects of sweetness and energy may be more easily observed in the female participants simply due to the comparatively low levels of overall consumption (approx. 2200 kcal. on day 1).

8.9.2.3. High and Low Consumers of Artificially-Sweetened Beverages in Responses to Sweetness (W vs. AS) and Energy (AS vs. NS)

Comparative levels of overall consumption can also be extended to explain the differences found between male high and low consumers. High consumers of artificially-sweetened beverages were found to demonstrate small responses to sweetness and energy, low consumers demonstrated no responses. Concurrently, high consumers consumed much lower levels of overall consumption than low consumers (high consumers - approx. 3100 kcal., low consumers - approx. 3900 kcal.). The overall levels of consumption in the high consumers may be comparatively low enough to allow responses to sweetness and energy to be detected. Thus, it may be that all male participants are responding to sweetness and energy but that these responses remain undetected in those consuming very high overall levels of food. This explanation however assumes that the male low consumers of artificially-sweetened beverages are responding to sweetness and energy. This explanation also suggests that no differences were found between male high and low consumers of artificially-sweetened beverages. These findings thus suggest the habitual consumption of sweetness without energy to have no effects on appetite in males.

The absence of effects of the high consumption of sweetness without energy in males may be suggested, as in the previous study, as a result of a low importance of taste in appetite in males. The differences found between males and females may also be explained by the importance of taste in appetite. Research has recently suggested taste to be considerably more influential in appetite in females than in males (Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998; Yeomans, 1996; Zylan, 1996; Beatty, 1982; Rolls, Fedoroff and Guthrie, 1991). It may be reasoned that if taste is more important in appetite in females than in males, females may be expected to respond more to taste manipulations than males and may be more influenced by taste-related stimuli.

8.9.2.4. Summary

In summary, in the male participants, few differences were found between consumers and no differences were found between sweetness/energy manipulations. These effects can be explained by comparison of the very small size of the effects of sweetness and energy on appetite, and the very large effects of overall levels of consumption on appetite. Differences between sweetness/energy manipulations were found in the high consumers. The lack of effects in low consumers has been attributed to the high overall levels of consumption of the low consumers.

8.9.3. ADDITIONAL FINDINGS

Other findings can also be noted from this study. Firstly, direct differences were found between males and females in behavioural measures of appetite. Males consumed more in test meal intake (weight of food, energy) than females. These findings are unsurprising and have frequently been reported elsewhere (see Rolls, Fedoroff and Guthrie, 1991).

Secondly, few differences were found between consumers or between sweetness/ energy manipulations in the subjective measures of appetite. This is probably due to the size of the effects on appetite of sweetness and energy, compared to the size of the effects on appetite of other variables, most notably, the time intervals between meals and the constraints on consumption by the experimental situation. The subjective measures of appetite were also concurrent with all behavioural measures. Expression of appetite in one measure may reduce the likelihood of expression in a concurrent measure (Wardle, 1987b).

No differences were also found in the measures of proportions of energy consumed from each macronutrient. This can be explained as a product of the provision of the test meals/snacks, and the specific test meals/snacks provided.

8.9.4. FINDINGS FROM STUDY 3 (SECTIONS 8.1 - 8.5)

In explaining the findings from this study, small consideration is also required of the findings in the previous study (sections 8.1 - 8.5). Whilst no effects were found in the previous study as a result of sweetness or energy, differences were found between consumers and were explained by differences between consumers in the perceived palatability of the preload drinks. Attempts were made in this study to minimize these differences between consumers (see section 8.6). Any differences possibly remaining however will not negate the effects found in this study. If a small effect of perceived palatability is considered to exist in the high consumers in response to the sweet preload drinks, the actual differences between consumers in response to sweetness and energy would be more extreme than those reported.

8.10 SUMMARY

In summary, this study has uncovered some interesting differences between high and low consumers of sweetness without energy. In female participants, compared to the low consumers, high consumers of sweetness without energy were found to demonstrate higher levels of appetite, a higher appetite for fluids, and no response to sweetness. Higher levels of overall appetite in the high consumers can be explained as a result of the uncoupling of sweetness and energy, as a demonstration of a sweetness-energy relationship that remains intact, but is often incorrect, or as a result of associations with the self-selected high consumption of artificial sweeteners as a result of high levels of the cognitive control of appetite. Higher levels of thirst are suggested to be a result of a high habitual fluid consumption. The absence of a response to sweetness is explained as a result of the habitual uncoupling of sweetness and energy as a demonstration of an extinction of the sweetness-energy relationship. In male participants, few differences were found. The absence of findings are probably due to the comparative high levels of overall consumption. The absence of effects in males and differences between males and females can be attributed to a lesser importance of taste in appetite in males.

Chapter 9.

STUDY 5:

UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE:

RESPONSES TO SWEETNESS WHEN CONSUMED AS A MEAL

ABSTRACT

This study investigates responses to sweetness as a meal in male and female, high and low consumers of artificially-sweetened beverages. Subjective and behavioural appetite were measured following 2 preload lunch manipulations (sweet, non-sweet). In subjective measures of appetite, effects in all participants were a combination of effects in male and female participants. In female participants, high consumers of <u>sweetened</u> beverages reported high levels of appetite for sweetness and high levels of appetite following sweetness, and higher levels of appetite for sweetness than low consumers. Low consumers reported similar levels of appetite for and following sweet and savoury tastes. These findings are explained by an increased palatability of sweetness to high consumers. Low consumers of <u>artificially-sweetened</u> beverages also reported decreases in all appetites following both preloads, compared to pre-lunch measures. High consumers reported increases in appetite for sweetness following the non-sweet lunch, compared to pre-lunch measures and similar levels of appetite for something savoury following a sweet lunch. These findings suggest an increased importance of taste in the high consumers of artificially-sweetened beverages, and differing responses to sweetness and energy may suggest an extinction of the sweetness-energy relationship. In male participants, few differences were found between high and low consumers of sweetened beverages and no differences were found between high and low consumers of artificially-sweetened beverages. The absence of effects in males and differences between males and females are attributed to the importance of taste in appetite. In behavioural measures of appetite, no differences were found between consumers.

9.1. INTRODUCTION

In the previous study (Study 4), in female participants, high and low consumers of sweetness without energy were found to demonstrate differing responses to sweetness. Low consumers demonstrated an increase in appetite in response to sweetness, high consumers demonstrated no response. In the previous study however, sweetness was provided only in fluid form. This study aims to investigate the appetitive responses to sweetness in solid form. To increase the strength of the manipulation, sweetness, furthermore, will be provided as a complete meal.

Findings in the previous study are also slightly confounded by possible differences between consumers in habitual consumption levels of sweetness and habitual consumption levels of hypotonic solutions. In this study, low consumers of artificially-sweetened beverages will additionally be defined as: high consumers of naturally-sweetened beverages, controlling for the sweet aspect of artificially-sweetened beverages; or high consumers of non-sweetened / low energy beverages, controlling for the low energy aspect of artificially-sweetened beverages. The high consumption of non-sweetened / low energy beverages however, is not considered to control for the potential hypotonicity of high artificially-sweetened beverage consumption. Hypotonicity was deemed impossible to control for in recruiting natural consuming consumers from a natural environment. The hypotonicity of a solution depends on the strength of the solution in terms of osmotically active substances (Carlson, 1986): strong artificially-sweetened beverages, strong tea and coffee may be hypertonic; weak naturally-sweetened beverages may be hypotonic. Hypotonicity however, also depends on the osmotic state of the consumer at the time of consumption (Carlson, 1986): for a dehydrated individual, almost all fluids are hypotonic; for an overhydrated individual, almost all fluids are hypertonic.

An attempt was also made in this study, in light of the two previous studies to increase the sensitivity of the subjective measures of appetite. In addition to the six questions on general appetite previously asked, participants were also asked three questions on specific appetites.

9.1.1. AIMS

This study aims to investigate the appetitive responses to sweetness in solid form in habitual high and habitual low consumers of sweetness without energy. Appetitive responses to sweetness will be investigated using subjective and behavioural measures of appetite following a sweet vs. a non-sweet meal. Habitual high and low consumers of sweetness without energy will be defined as in Chapter 7. Low consumers will additionally be defined either as high consumers of naturally-sweetened beverages or high consumers of non-sweet/low energy beverages.

9.2. METHOD

9.2.1. DESIGN

The study uses a 2 x 3 x 2 mixed design, investigating gender (2 levels), consumer type (3 levels), and sweetness manipulation (2 levels). The study was conducted using a preloading procedure, where sweetness manipulation was given as a preload lunch and appetite was subsequently measured using subjective and behavioural measures.

9.2.2. CONSUMERS

Three independent groups of consumers participated in the study - habitual high consumers of artificially-sweetened beverages (AC), habitual low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC), and habitual low consumers of artificially-sweetened beverages but high consumers of non-sweet / low energy beverages (WC). Habitual high consumers of artificially-sweetened beverages (AC) were required to be consuming ≥ 825 ml (artificially-sweetened beverages)/day. Habitual high consumers of naturally-sweetened beverages (NC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (naturally-sweetened beverages)/ day. Habitual high consumers of non-sweet / low energy beverages (WC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (non-sweet/low energy beverages)/day. Consumption levels of all beverages were reported by all participants on a self-report Drinks F.F.Q., completed prior to inclusion in the study (see Appendix 8.1). Naturally-sweetened beverages were considered to be tea or coffee sweetened with natural sweeteners (sugar, honey), fruit juices, regular carbonated drinks, regular squash, hot chocolate, and milkshakes. Non-sweet / low energy beverages were considered to be unsweetened tea or coffee or water. Equal numbers of males and females participated in the study.

In total, 16 habitual high artificially-sweetened beverage consumers (AC)(8 male and 8 female), 16 habitual high naturally-sweetened beverage consumers (NC)(8 male and 8 female) and 16 habitual high non-sweet beverage consumers (WC)(8 male and 8 female) took part in the study. Prior to the start of the study, all participants were measured for calculation of B.M.I. and completed the D.E.B.Q., as a measure of dietary restraint. Consumer groups were matched as closely as possible on B.M.I. and dietary restraint (D.E.B.Q.-R.) scores. All participants were familiar with and moderately liked all foods in the study. None of the participants were informed of the exact hypotheses of the study. Participant characteristics are displayed in Table 9.1.

Table 9.1: Participant Characteristics (mean (standard deviation))

Participants	Beverage Consumption (ml/day)				
	Artificially-Sweetened	Total Sweetened	Total	B.M.I. (kg/m^2)	D.E.B.Q.-R. score
WC - M (N=8)	0.0 (0.0)	409.1 (196.6)	1960.4 (459.5)	22.9 (2.9)	13.4 (4.6)
WC - F (N=8)	0.0 (0.0)	362.1 (227.6)	1840.7 (458.5)	21.5 (2.3)	31.8 (6.8)
AC - M (N=8)	1113.8 (352.5)	1389.3 (339.7)	2178.1 (577.4)	24.9 (6.2)	16.6 (5.2)
AC - F (N=8)	1860.7 (1090.3)	2058.7 (983.3)	2813.8 (1017.9)	22.5 (5.5)	24.4 (3.8)
NC - M (N=8)	0.0 (0.0)	1470.5 (420.1)	1845.5 (775.9)	25.1 (2.1)	28.3 (6.6)
NC - F (N=8)	0.0 (0.0)	1294.5 (363.2)	1514.1 (350.4)	24.2 (2.9)	30.6 (10.5)

Participant: WC = WC consumers, AC = AC consumers, NC = NC consumers; M = Male, F= Female

9.2.3. SWEETNESS MANIPULATIONS

The sweetness manipulations were given as a preload lunch. The two manipulations were:

- Sweet Lunch - consisting of banana and cream cheese sandwiches (281.7g), toffee popcorn (20g), jam swiss roll (39g).
- Non-sweet Lunch - consisting of cottage cheese and lettuce sandwiches (255g), crisps (30.8g), water biscuits with cream cheese (49.2g).

Exact recipes for the two lunches, energy and macronutrient contents of all foods used are given in Appendix 9.1. The two lunches were equal in weight of food, energy content and all macronutrient proportions, and were similar in appearance. Weight, energy content, and all macronutrient proportions are given below in Table 9.2. Lunches was fixed at 10% less than that consumed from ad-libitum versions of these lunches (see Delargy, PhD thesis, 1997). Females were given a smaller lunch than males (75%). Both meals were piloted prior to the study to ensure each was palatable and of a manageable size. Both meals were also rated after consumption by each participant on 100mm V.A.S. of Pleasantness, Tastiness, Sweetness and Saltiness. Both lunches were designed to be equally pleasant and tasty, but to differ greatly in sweetness and saltiness.

All participants experienced both lunches, each on a separate study day, approximately one week apart. Order of presentation was counterbalanced across all participants.

Table 9.2: Weight, Energy Content and all Macronutrient Proportions of the Sweet and Non-Sweet Preload Lunches - Quantities for Male Participants

	Sweet Lunch	Non-Sweet Lunch
Weight of Food (gram.)	340.7	335.0
Energy Content (kcal.)	706.6	709.0
Carbohydrate Content (gram. (%kcal.))	139.9 (74.2%)	130.6 (69.1%)
Fat Content (gram. (%kcal.))	12.0 (15.3%)	13.1 (16.6%)
Protein Content (gram. (%kcal.))	18.2 (10.3%)	24.2 (13.7%)

9.2.4 MEASURES OF SUBSEQUENT APPETITE

Subsequent appetite was measured using subjective and behavioural measures.

9.2.4.1. Subjective Measures

Subjective perceptions of appetite were measured using 100mm V.A.S. of Hunger, Desire to Eat, Fullness, Prospective Consumption, Thirst and Desire to Drink. Subjective perceptions of specific appetites were also measured using 100mm V.A.S. of Appetite for Something Sweet, Appetite for Something Savoury, and Appetite for a Meal. Subjective perceptions were measured throughout the day, as detailed in section 9.2.5.

9.2.4.2. Behavioural Measures

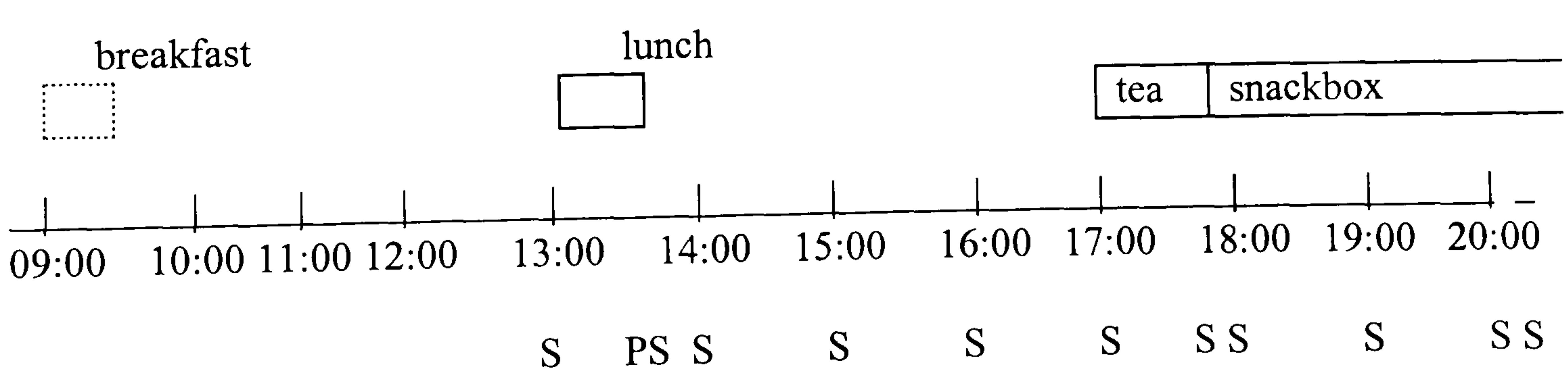
Behavioural expressions of appetite were measured using extent of consumption in two subsequent ad-libitum test meals/periods (test meal intake). Test Meal Intake in all test meals was measured as weight of food consumed (gram.), energy consumed (kcal.) and proportions of all macronutrients consumed (%kcal.). The test meals/periods were tea and evening snack consumption. Tea was composed of: vegetable lasagne, peas, digestive biscuits, apples and water. The evening snackbox was composed of: bread rolls, margarine portions, cheese portions, jam portions, individual packets of crisps, individual packets of biscuits, apples and yoghurts. All foods were served in excess. Recipes and the energy and macronutrient content of all foods can be found in Appendix 9.2. All drinks consumed in conjunction with the snackbox were recorded by the participants.

Results are provided for each individual test meal - Individual Test Meal Intake (tea intake, evening snack intake), and for a summation of all intake throughout the day - Cumulative Test Meal Intake (following tea, end of Day 1).

9.2.5. PROCEDURE

A time line of each study day is shown in Figure 9.1. On each study day all participants were required to be in the Human Nutrition Unit from 13:00 to 13:45 and from 17:00 to 17:45. At all other times, participants were free to behave as normal, but were instructed to refrain from eating or drinking anything except water. All participants consumed their own breakfast at home on each day, were instructed to keep each breakfast as standard as possible on each study day and were asked to record each breakfast on arrival in the unit. Any differences in breakfast consumption were calculated using food composition tables and were added into cumulative intakes across the day. All study days were identical, excepting the preload lunch received.

Figure 9.1: Time Line of Each Study Day in Study 5.



S = Completion of Subjective Measures of Appetite
P = Completion of Subjective Measures of Lunch Palatability

9.2.6. ANALYSIS

Participant Characteristics: Prior to analysis of the dependent measures in this study, all consumer groups were compared in artificially-sweetened beverage consumption, total sweetened beverage consumption, B.M.I. and Dietary Restraint Score. Groups of high (AC) and low (WC, NC) consumers were designed to differ in artificially-sweetened beverage consumption. Groups of AC and NC consumers were designed to be similar in terms of total sweetened beverage consumption. All groups were designed to be similar in terms of B.M.I. and Restraint. If differences were found between consumer groups, or if a significant relationship was found between B.M.I. and/or Dietary Restraint and Total Test Meal Intake on Day 1 (kcal.), B.M.I. and/or Dietary Restraint Score were included in all analyses as covariates. Participant characteristics were analysed by 1-way ANOVA (6 groups) and Pearson Product Moment Correlations.

Methodological Characteristics: Prior to analysis of the dependent measures in this study, all preloads were also compared in palatability. Preloads were designed to differ in terms of sweetness and saltiness, but were designed to be similar in terms of pleasantness and tastiness, and were designed to be similar to all consumers. Methodological characteristics were analysed by 2-way ANOVA (consumer group by preload) and Pearson Product Moment Correlations.

Subjective Measures of Appetite: All subjective measures of appetite are described as temporal profiles and were analysed using 4-way mixed ANCOVA (gender by consumer by preload lunch by time, covariates - B.M.I., dietary restraint score). Data for male participants were also analysed separately using 3-way mixed ANCOVA (consumer by preload by time, covariates - B.M.I., dietary restraint score). Data for female participants were analysed separately using 3-way mixed ANOVA (consumer by preload by time). Student-Newman-Keuls t-tests were used to investigate significant ANOVA/ANCOVA results. Where effects of time are not to be included in analyses Area Under the Curve (A.U.C.) (Hulshof, de Graaf, and Westrate, 1993) is used. Due to the number of significant differences found in the subjective measures of appetite, results will be reported as subjective measures of hunger (scales of hunger, desire to eat, fullness and prospective consumption), subjective measures of thirst (scales of thirst and desire to drink), subjective measures of appetite for something sweet, subjective measures of appetite for something savoury, and subjective measures of appetite for a meal. Due to the constraints of the statistical tests used, subjective ratings were collapsed across some time points, and analyses for multi-way interactions were not always conducted.

Behavioural Measures of Appetite: Individual and Cumulative Intake were analysed using 3-way mixed ANCOVA (gender by consumer by preload, covariate - Dietary Restraint Score). Data for male participants was also analysed using 2-way mixed ANCOVA (consumer by preload, covariate - Dietary Restraint Score). Data for female participants was analysed using 2-way mixed ANOVA (consumer by preload). Student-Newman-Keuls t-tests were used to investigate significant ANOVA/ANCOVA results. Data is recorded as missing for proportions of macronutrient consumed if nothing was consumed in a test meal/period.

Due to the amount of data collected, only systematic significant differences are reported below in the text. Significant differences were considered systematic if patterns of similar differences were found in related data (e.g. in lunch and tea intake). All significant differences are reported in the appendices with results tables.

9.3. RESULTS

Note: WC consumers = low consumers of artificially-sweetened beverages, high consumers of non-sweetened beverages; AC = high consumers of artificially-sweetened beverages; NC consumers = low consumers of artificially-sweetened beverages, high consumers of naturally-sweetened beverages.

9.3.1. PARTICIPANT CHARACTERISTICS

9.3.1.1. Artificially-Sweetened Beverage Consumption

High (AC) and low (WC, NC) consumers were designed to differ in artificially-sweetened beverage consumption. Significant differences were found between consumer groups ($F(5,47)=23.60$, $p<0.001$). Male AC consumers consumed more artificially-sweetened beverages than male and female, WC and NC consumers (all: $t(14)=-8.94$, $p<0.001$). Female AC consumers consumed more artificially-sweetened beverages than male and female, WC and NC consumers (all: $t(14)=-4.83$, $p<0.001$). No significant differences were found between male and female AC consumers ($t(14)=-1.84$, $p=0.09$), or between male and female WC and NC consumers.

9.3.1.2. Total Sweetened Beverage Consumption

High consumers of artificially-sweetened beverages (AC) and high consumers of naturally-sweetened beverages (NC) were also designed not to differ in total sweetened beverage consumption. No significant differences were found ($F(5,47)=2.73$, $p=0.06$). (The closeness of this similarity is due to extremely high consumption levels by one female consumer.)

9.3.1.3. B.M.I.

Groups of consumers were designed to be similar in B.M.I. No differences were found between consumer groups in B.M.I. ($F(5,47)=1.02$, $p=0.41$). Significant relationships were found however, between B.M.I. and total Test Meal Intake on Day 1 in all participants ($r=0.363$, $p=0.01$) and in male participants ($r=0.449$, $p=0.03$). No relationship was found in female participants ($r=0.127$, $p=0.56$).

Due to the significant relationships and the potential influence on appetite of B.M.I., B.M.I. was used as a covariate in all analyses on all participants and on male participants. B.M.I. was not used as a covariate in any analyses on female participants. The significance of the covariate in all analyses in which it was used, are shown in Appendices 9.9 - 9.10.

9.3.1.4. Dietary Restraint

Groups of consumers were designed to be similar in Dietary Restraint. Significant differences however, were found between consumer groups in D.E.B.Q.-R. scores ($F(5,47)=10.54$, $p<0.001$). Male WC consumers were significantly less restrained than male AC consumers, female AC consumers, female WC consumers and female NC consumers (smallest $t(14)=-4.26$, $p=0.001$). Male NC consumers were significantly less restrained than male AC consumers, female AC consumers, female WC consumers and female NC consumers (smallest $t(14)=-3.38$, $p=0.004$). No significant differences were found between male WC and NC consumers ($t(14)=-1.32$, $p=0.21$), or between the four more highly restrained groups (male AC, female WC, AC, NC) (largest $t(14)=2.68$, $p=0.02$ (adjusted significance)). A significant relationship was found between Restraint and total Test Meal Intake on Day 1 in all participants ($r=-0.462$, $p=0.001$). No relationship was found in male participants only ($r=-0.370$, $p=0.08$) or in female participants only ($r=0.021$, $p=0.92$).

Due to the differences found between groups, the significant relationship and the potential influence on appetite of dietary restraint, D.E.B.Q.-R. score was used as a covariate in all analyses on all participants and in all analyses on male participants. Dietary restraint was not used as a covariate in any analyses on female participants. The significance of the covariate in all analyses in which it was used, are shown following all analyses in Appendices 9.11 - 9.12.

B.M.I. and Dietary Restraint score were not related (all participants: $r=0.110$, $p=0.46$; male participants: $r=0.254$, $p=0.23$).

9.3.2. METHODOLOGICAL CHARACTERISTICS

9.3.2.1. Preload Palatability

The two preload lunches were designed to differ in sweetness and saltiness. Significant differences between lunches were found in the designed direction (sweetness: $F(1,42)=752.72$, $p<0.001$; saltiness: $F(1,42)=305.83$, $p<0.001$). The two lunches were also designed to be similar in pleasantness and tastiness. No differences were found between the lunches in pleasantness ($F(1,42)=0.21$, $p=0.65$). Differences were found in tastiness ($F(1,42)=6.16$, $p=0.02$) . All participants rated the sweet lunch as more tasty than the non-sweet lunch. No relationships were found between ratings of pleasantness or tastiness and subsequent consumption (pleasantness: $r=0.16$, $p=0.17$, tastiness: $r=0.17$, $p=0.11$).

Differences between consumers were found in scales of pleasantness ($F(5,42)=3.09$, $p=0.02$) and tastiness ($F(5,42)=2.64$, $p=0.04$). Male WC consumers rated both lunches more pleasant than male AC consumers ($t(14)=3.01$, $p=0.01$) and female AC consumers ($t(14)=2.58$, $p=0.02$). No other differences were found (largest $t(14)=2.24$, $p=0.04$ (adjusted significance)). Female NC consumers rated both lunches more tasty than male NC consumers ($t(14)=-2.74$, $p=0.02$). No other differences were found (largest $t(14)=-2.37$, $p=0.04$ (adjusted significance)). No significant differences were found between consumers in ratings of sweetness or saltiness (largest $F(5,42)=3.53$, $p=0.08$). No relationships were found between ratings of pleasantness, tastiness, sweetness or saltiness and subsequent consumption (all participants: largest $r=0.176$, $p=0.23$; male participants: largest $r=-0.208$, $p=0.33$; female participants: largest $r=-0.190$, $p=0.19$). A significant correlation was found however between ratings of pleasantness and tastiness ($r=0.76$, $p<0.001$). No consumer by preload interactions were found (largest $F(5,42)=1.76$, $p=0.14$). Ratings of Preload Lunches are shown in Table 9.3, and are shown (with analysis) in Appendix 9.3.

Table 9.3: Ratings of Preload Lunches (means, (standard deviations))

Consumer Group	Preload			
	Sweet Lunch		Non-Sweet Lunch	
	Pleasantness	Tastiness	Pleasantness	Tastiness
M - WC	68 (14)	71 (12)	69 (12)	59 (12)
M - AC	55 (20)	66 (11)	43 (15)	35 (21)
M - NC	46 (20)	47 (18)	61 (19)	51 (21)
F - WC	63 (29)	68 (29)	60 (18)	50 (26)
F - AC	44 (19)	48 (17)	60 (27)	54 (27)
F - NC	71 (7)	72 (10)	65 (21)	59 (22)

Due to the differences found between groups and the potential influence on appetite of pleasantness and tastiness, tastiness ratings were used as a covariate in analysis. Due to the constraints of the statistical tests used, tastiness was only used as a covariate for differences between consumer groups. Differences between preloads in terms of tastiness are not considered in analysis of the data, but will be considered in interpreting all findings. Tastiness ratings were used as a covariate in all analyses on all participants and in all analyses on male participants. Tastiness was not used as a covariate in any analyses on female participants. The significance of the covariate in all analyses in which it was used, are shown following all analyses in Appendices 9.11 - 9.12.

Tastiness ratings were not correlated with B.M.I. or Dietary Restraint score (B.M.I. - all participants: $r=-0.07$, $p=0.51$; male participants: $r=0.22$, $p=0.13$; Dietary Restraint Score - all participants: $r=-0.11$, $p=0.26$; male participants: $r=-0.24$, $p=0.10$).

9.3.3. SUBJECTIVE MEASURES OF APPETITE

9.3.3.1. All Participants

Subjective Measures of Hunger:

Significant differences were found between genders in the scale of Desire to Eat ($F(1,40)=3.95$, $p=0.05$). Males reported higher levels of desire to eat than females. No significant differences were found between consumers (largest $F(2,42)=0.99$, $p=0.38$) or preloads (largest $F(1,42)=3.78$, $p=0.06$). Significant interactions between consumer and preload were found in scales of hunger ($F(2,42)=3.97$, $p=0.03$) and desire to eat ($F(2,42)=5.93$, $p=0.005$) (see Figures 9.2 and 9.3).

Figure 9.2: Interaction Graph for Subjective Measures of HUNGER - All Participants - Consumer by Preload

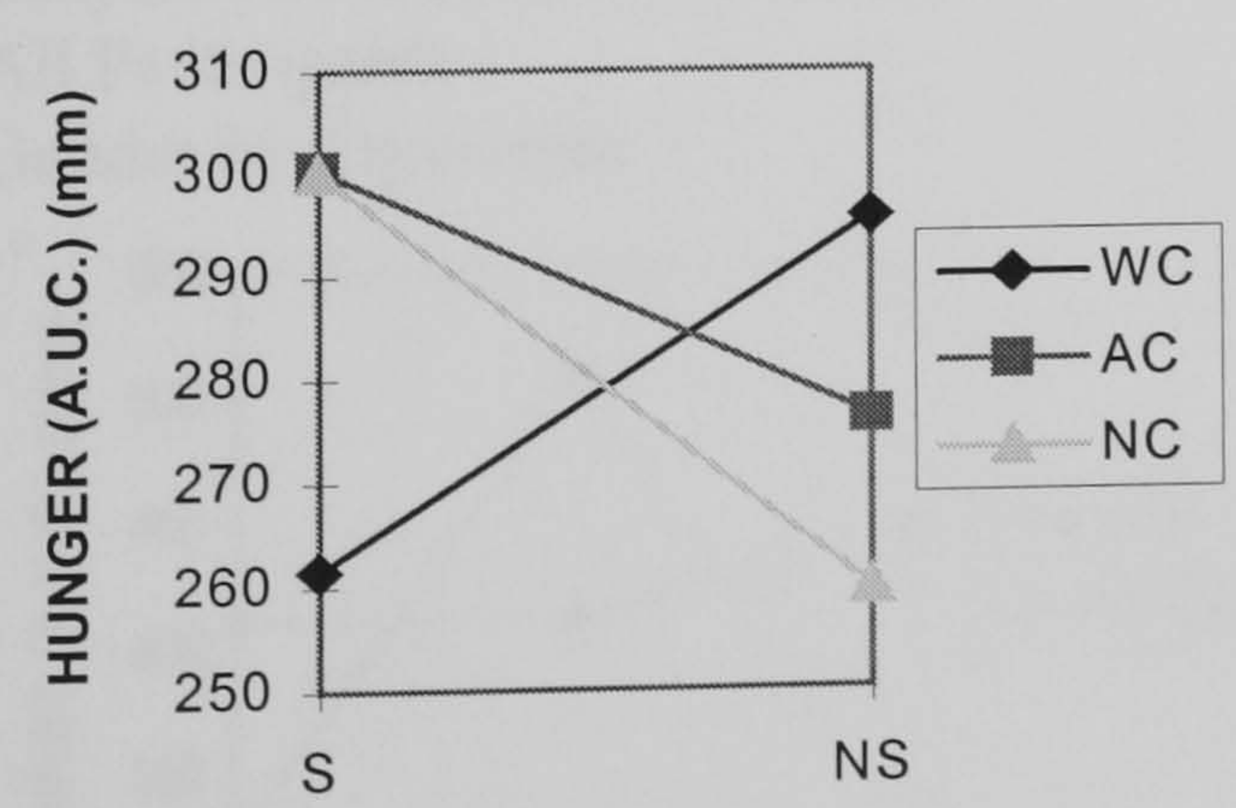
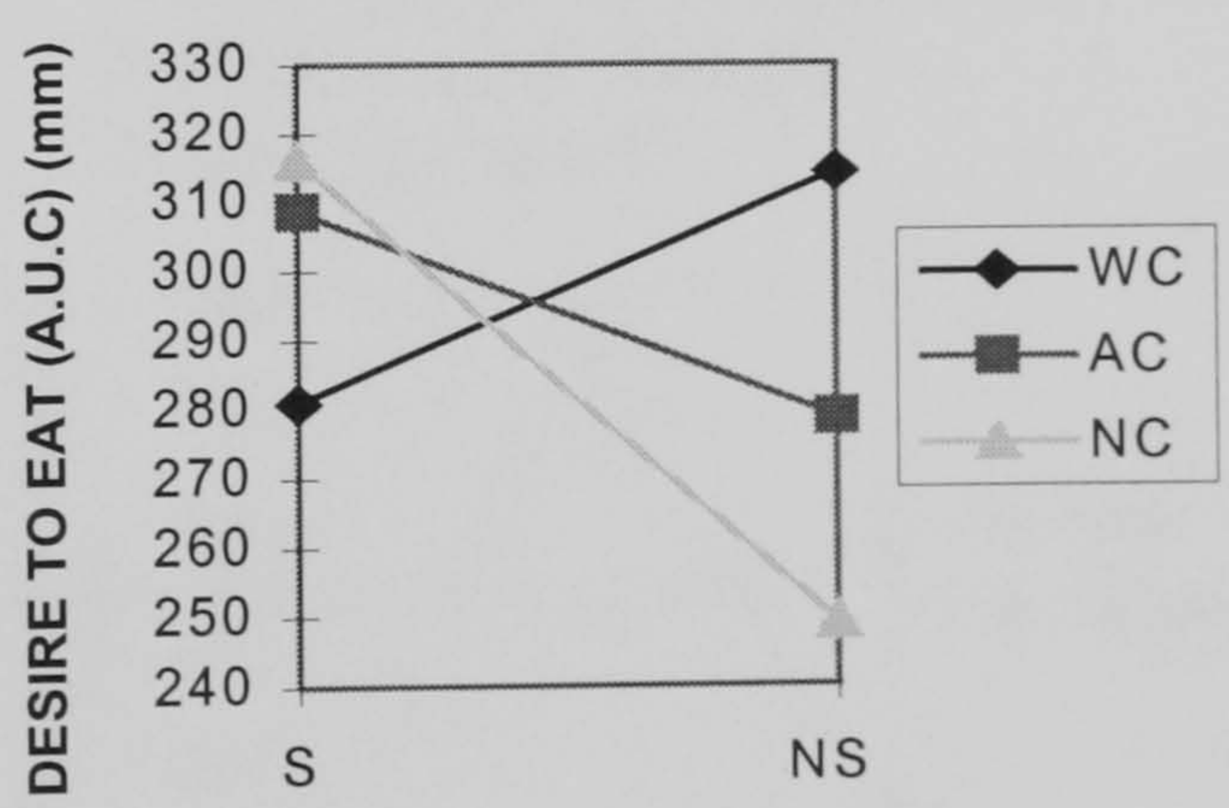


Figure 9.3: Interaction Graph for Subjective Measures of DESIRE TO EAT- All Participants - Consumer by Preload



WC consumers and AC consumers reported similar levels of hunger following the non-sweet lunch and following the sweet lunch (WC hunger $t(15)=1.39$, $p=0.19$; desire to eat $t(15)=-1.39$, $p=0.18$; AC hunger $t(15)=-1.24$, $p=0.23$; desire to eat $t(15)=-1.24$, $p=0.23$) NC consumers reported less hunger following the non-sweet lunch than following the sweet lunch (hunger $t(15)=-2.73$, $p=0.02$; desire to eat $t(15)=-4.02$, $p=0.001$). Significant effects of time were found in all scales (smallest $F(10,420)=112.92$, $p<0.001$). No other systematic interactions were found. The temporal profile for subjective measures of Hunger and Desire to Eat (Gender by Time) are shown in Appendices 9.4 - 9.5.

Subjective Measures of Thirst:

No significant differences were found between genders (largest $F(1,39)=3.38$, $p=0.07$). Significant differences were found between consumers (smallest $F(2,39)=3.22$, $p=0.05$) (see Figure 9.6). AC consumers of artificially-sweetened beverages reported higher levels of thirst than WC consumers (smallest $t(30)=2.72$, $p=0.01$) and NC consumers (smallest $t(30)=-2.70$, $p=0.01$). No differences were found between WC and NC consumers (largest $t(30)=0.36$, $p=0.72$). Significant interactions were found between gender and consumer (smallest $F(2,39)=7.96$, $p=0.001$) (see Figures 9.4 and 9.5). In male participants, no differences were found between consumer groups in scales of thirst (largest $t(14)=-1.31$, $p=0.21$) or desire to drink (largest $t(14)=-0.83$, $p=0.42$); in female participants, AC consumers reported higher levels of thirst and desire to drink than WC consumers (thirst: $t(14)=-4.62$, $p<0.001$; desire to drink: $t(14)=-4.46$, $p=0.001$) and NC consumers (thirst: $t(14)=6.12$, $p<0.001$; desire to drink: $t(14)=5.28$, $p<0.001$). No differences were found between female WC and NC consumers (thirst: $t(14)=0.19$, $p=0.85$; desire to drink: $t(14)=-0.12$, $p=0.90$). Significant differences were found between preloads in the scale of thirst ($F(2,42)=6.21$, $p=0.02$) (see Figure 9.7). All participants reported higher levels of thirst following the non-sweet lunch than following the sweet lunch. Consistent significant effects of time were found (smallest $F(10,420)=24.34$, $p<0.001$).

Figure 9.4: Interaction Graph for Subjective Measures of THIRST - All Participants - Gender by Consumer

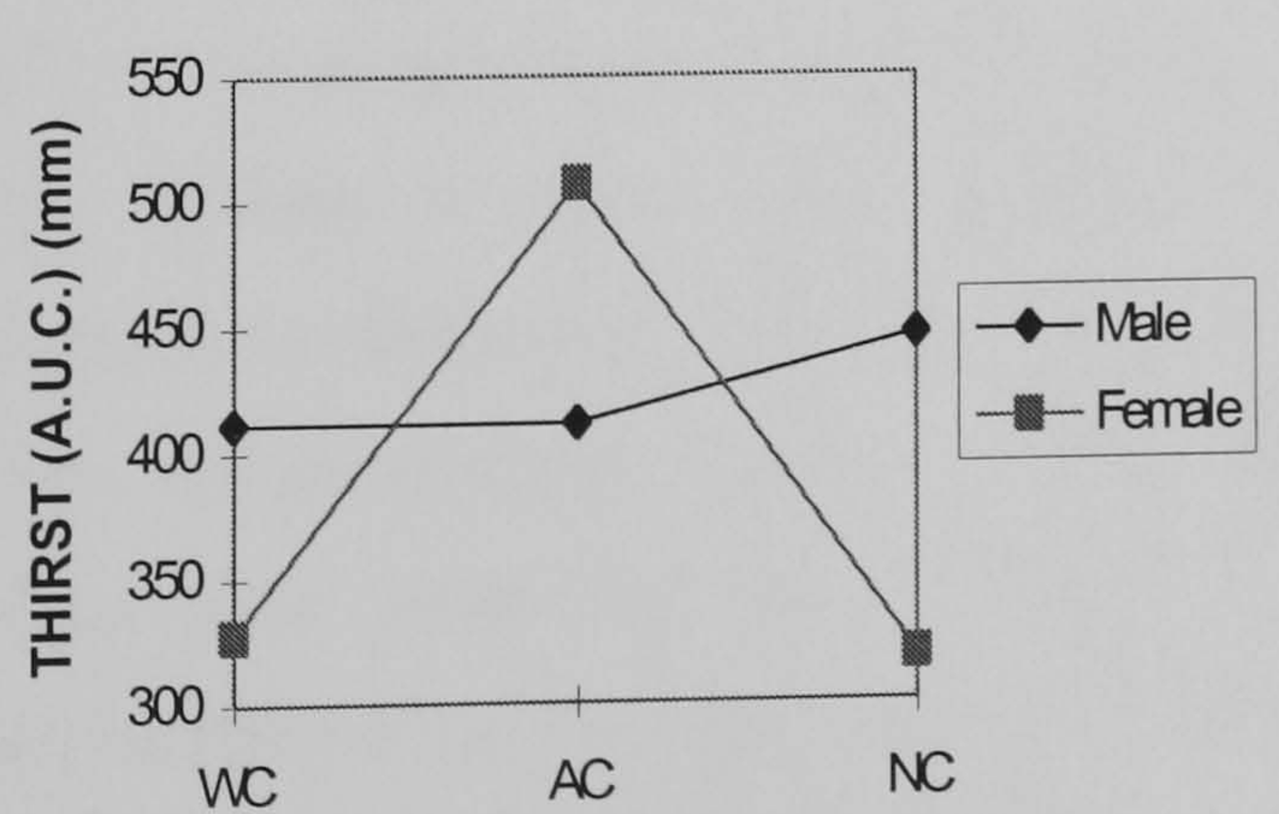


Figure 9.5: Interaction Graph for Subjective Measures of DESIRE TO DRINK - All Participants - Gender by Preload

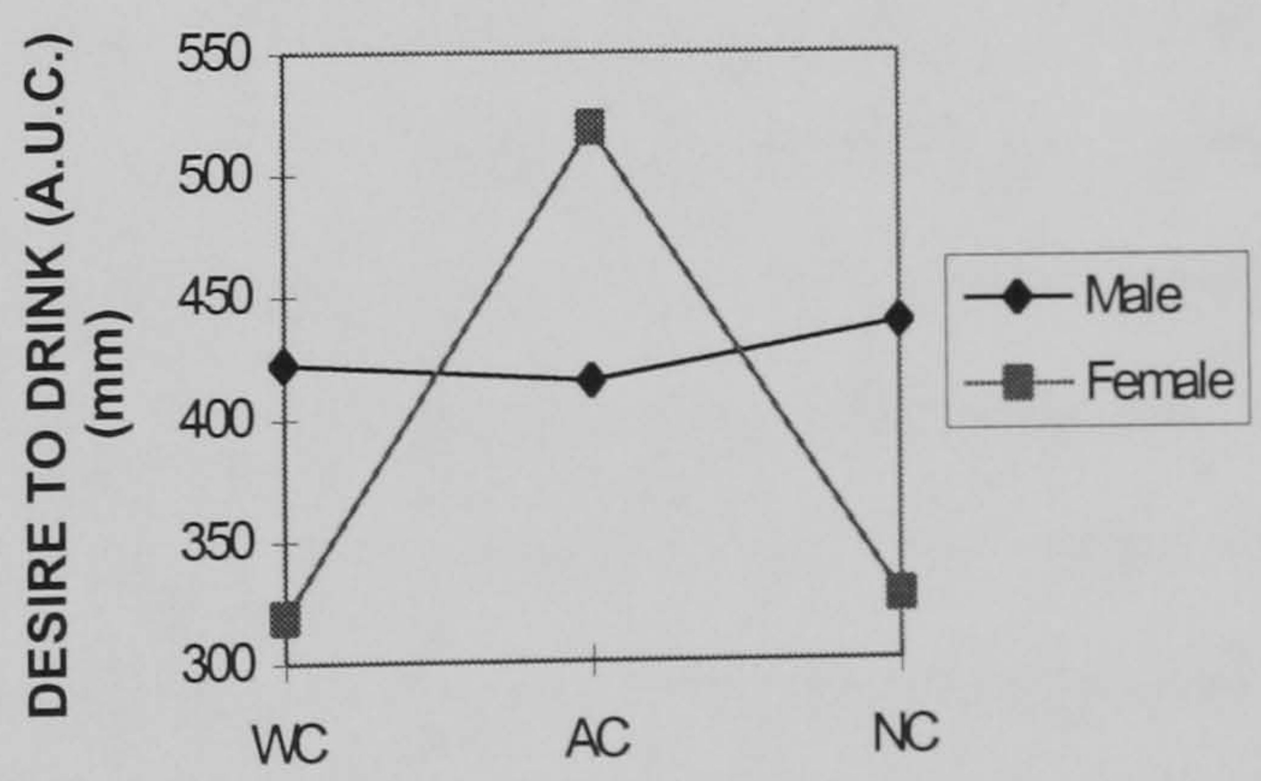


Figure 9.6: Temporal Profile for Subjective Measures of THIRST - All Participants - Consumer by Time

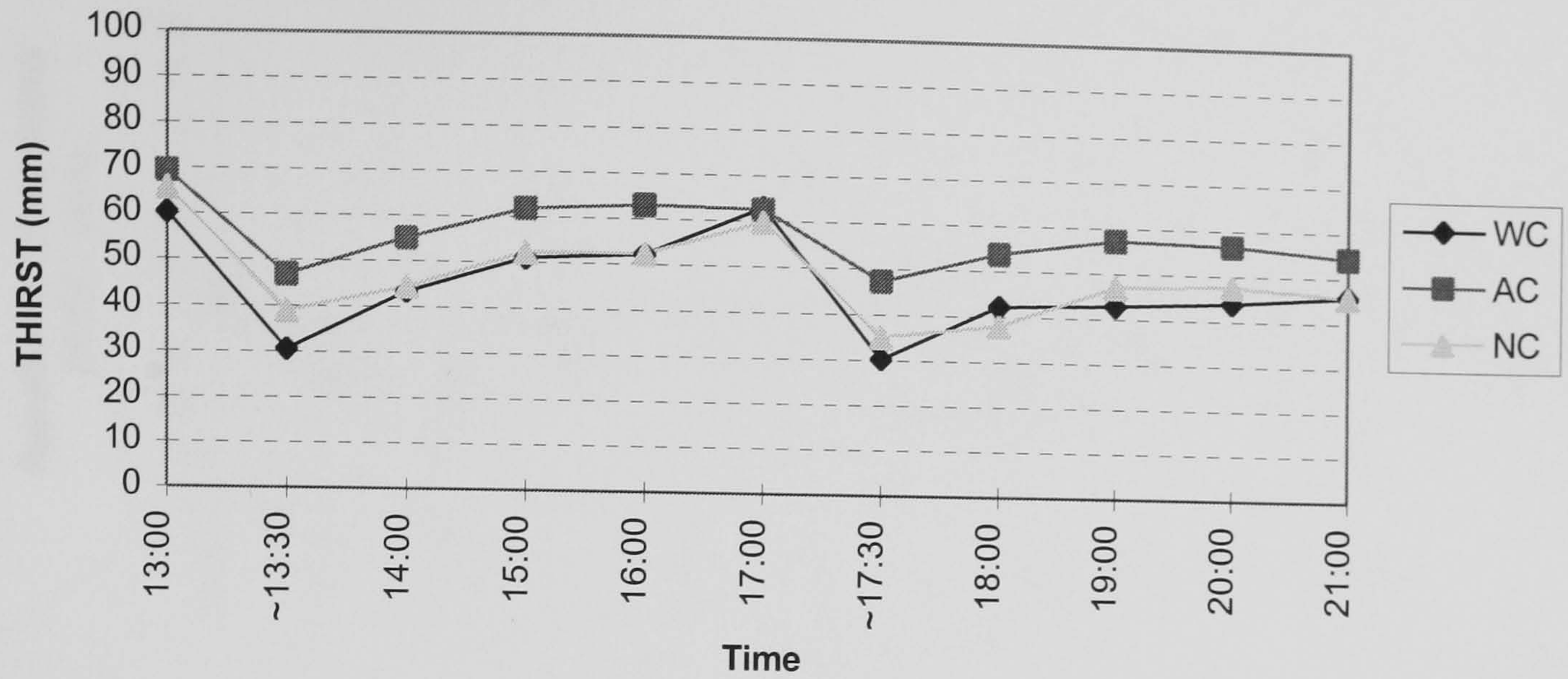
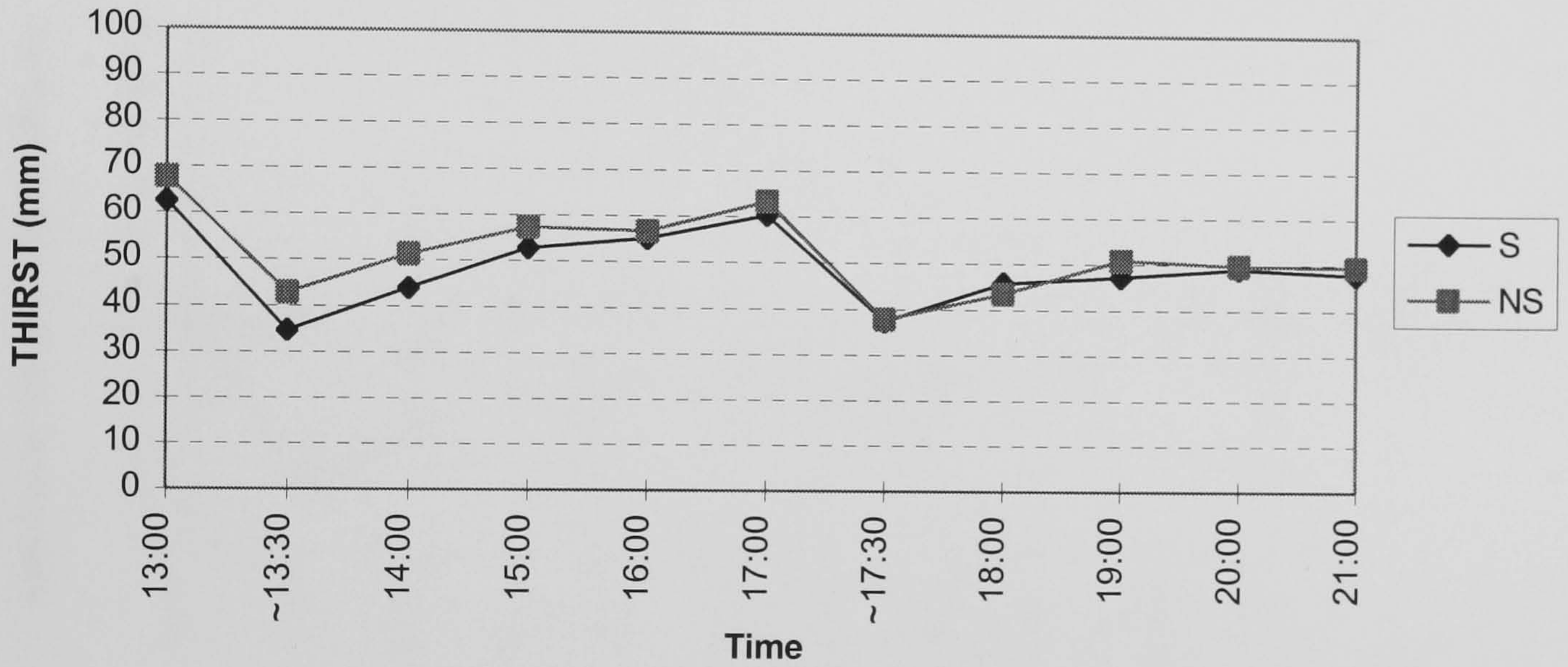


Figure 9.7: Temporal Profile for Subjective Measures of THIRST - All Participants - Preload by Time



Subjective Measures of Appetite for Something Sweet:

No significant differences were found between genders ($F(1,39)=0.85$, $p=0.36$). Significant differences were found between consumers ($F(2,39)=4.49$, $p=0.02$) (see Figure 9.8). WC consumers reported a lower appetite for something sweet than AC consumers ($t(30)=-2.69$, $p=0.01$) and demonstrated a similar trend compared to NC consumers ($t(30)=1.77$, $p=0.09$). No differences were found between AC and NC consumers ($t(30)=1.61$, $p=0.12$). Significant differences were found between preloads ($F(1,42)=31.84$, $p<0.001$) (see Figure 9.9). All participants reported a lower appetite for something sweet following the sweet meal than following the non-sweet meal. Significant effects of time were found ($F(10,420)=13.05$, $p<0.001$). Significant interactions were found between preload and time ($F(10,420)=13.01$, $p<0.001$) (see Figure 9.9). All participants demonstrated a lower appetite for something sweet following the sweet meal than following the non-sweet meal throughout the afternoon. No differences were found in the evening.

Figure 9.8: Temporal Profile for Subjective Measures of Appetite for Something Sweet - All Participants - Consumer by Time

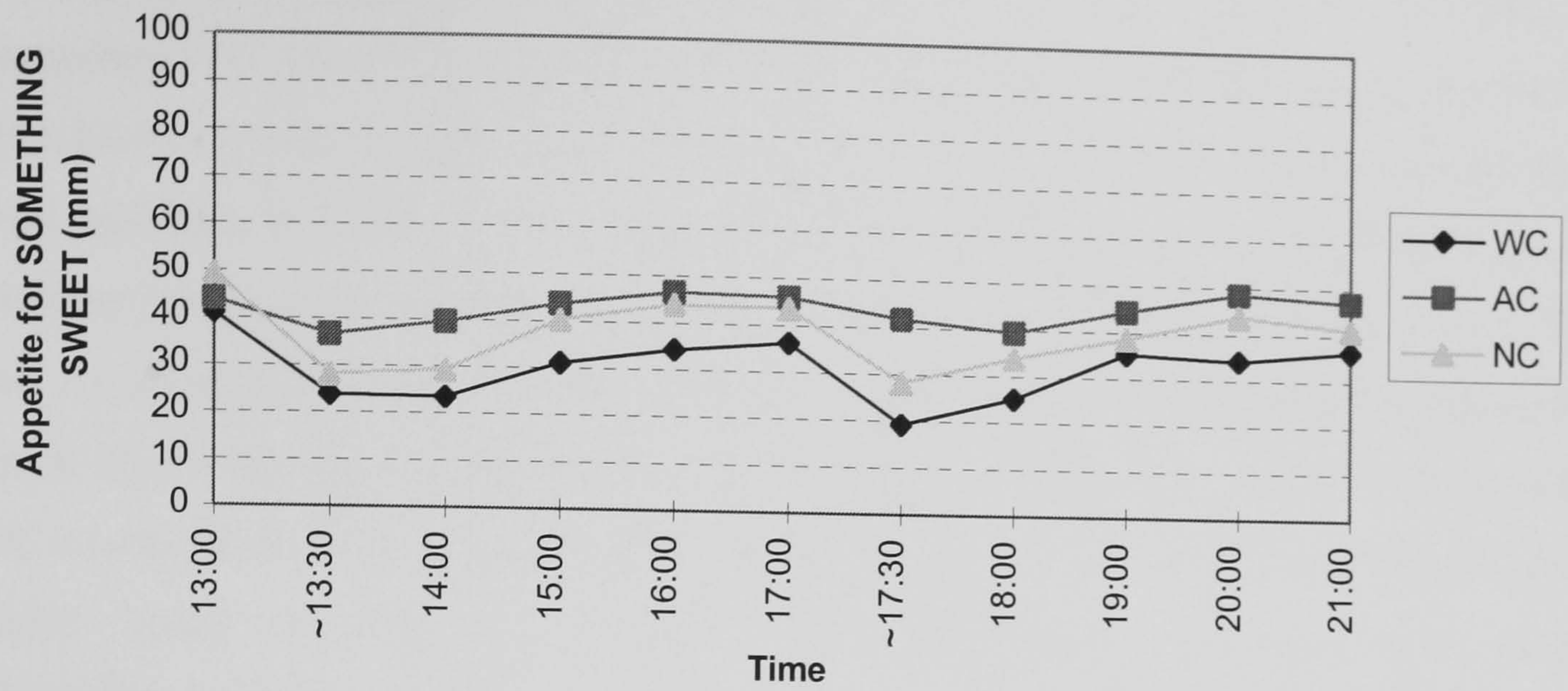
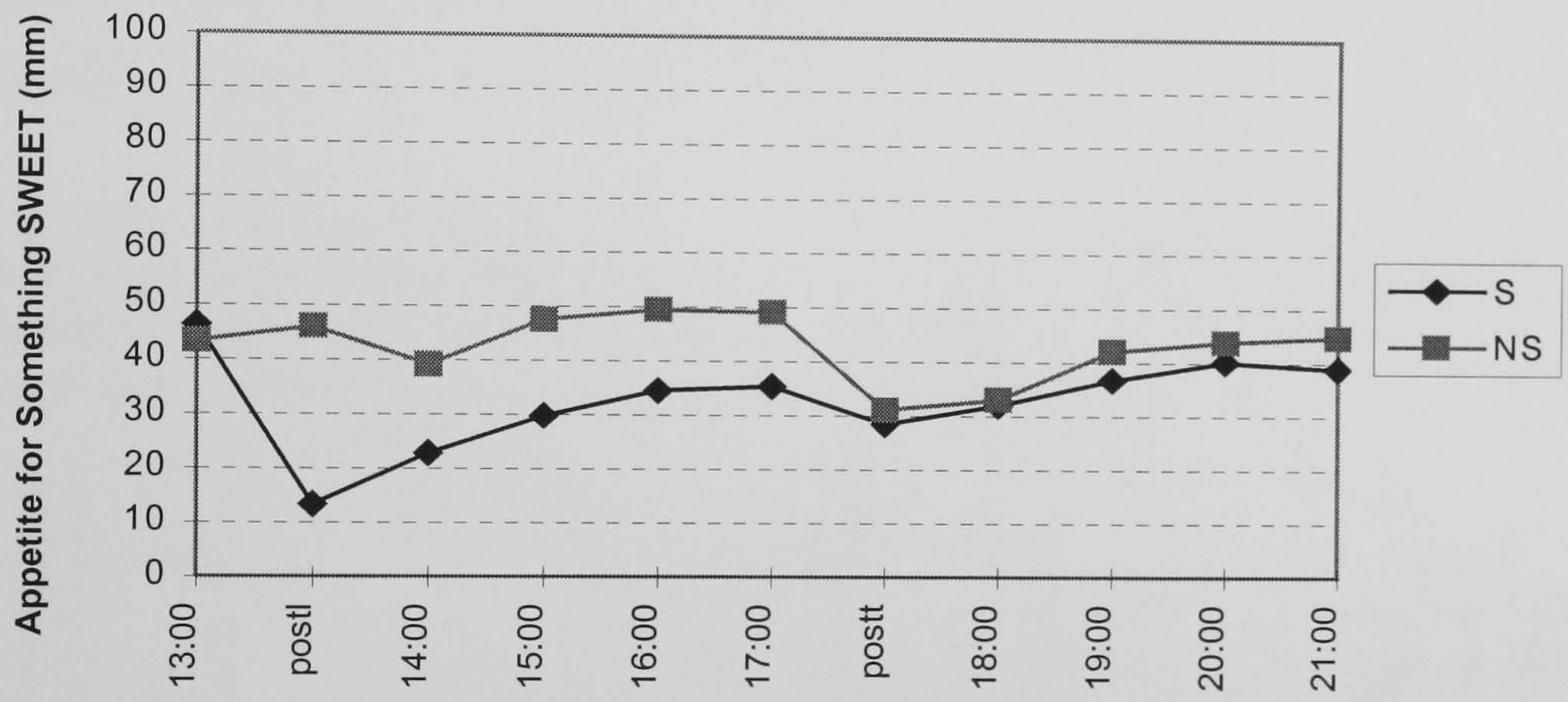


Figure 9.9: Temporal Profile for Subjective Measures of Appetite for Something SWEET - All Participants - Preload by Time



Subjective Measures of Appetite for Something Savoury:

No significant differences were found between genders ($F(1,39)=2.24$, $p=0.14$), or consumers ($F(1,39)=0.29$, $p=0.75$). Significant differences were found between preloads ($F(1,42)=24.09$, $p<0.001$) (see Figure 9.12). All participants reported a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch. Significant interactions between consumer and preload were found ($F(2,42)=5.73$, $p=0.006$) (see Figure 9.10). WC consumers reported <u>similar</u> levels of appetite for something savoury following the sweet and the non-sweet lunch ($t(15)=-0.35$, $p=0.73$), AC and NC consumers reported a <u>lower</u> appetite following the non-sweet than the sweet lunch (AC: $t(15)=-4.54$, $p<0.001$; NC: $t(15)=-3.89$, $p=0.001$). Significant effects of time were found ($F(10,420)=82.82$, $p<0.001$). Significant interactions were found between preload and time ($F(10,420)=7.76$, $p<0.001$) (see Figure 9.12). All participants demonstrated a lower appetite for something savoury following the non-sweet meal than following the sweet meal, throughout the afternoon. No differences were found in the evening.

Subjective Measures of Appetite for a Meal:

No significant differences were found between genders ($F(1,39)=1.01$, $p=0.32$), or consumers ($F(1,39)=0.26$, $p=0.77$). Significant differences were found between preloads ($F(1,42)=5.86$, $p=0.02$) (see Figure 9.13). All participants reported a lower appetite for a meal following the non-sweet lunch than following the sweet lunch. Significant interactions between consumer and preload were found ($F(2,42)=3.46$, $p=0.04$) (see Figure 9.11). WC and AC consumers reported <u>similar</u> levels of appetite for a meal following the non-sweet lunch than following the sweet lunch (WC $t(15)=0.42$, $p=0.68$; AC $t(14)=-1.42$, $p=0.18$), NC consumers reported a <u>lower</u> appetite following the non-sweet lunch than following the sweet lunch ($t(14)=-4.49$, $p<0.001$). Significant effects of time were found ($F(10,420)=148.52$, $p<0.001$). Significant interactions were found between preload and time ($F(10,420)=2.67$, $p=0.004$) (see Figure 9.13). All participants demonstrated a lower appetite for a meal following the non-sweet lunch than following the sweet lunch throughout the afternoon. No differences were found throughout the evening.

Figure 9.10: Interaction Graph for Subjective Measures of Appetite for Something SAVOURY - All Participants - Consumer by Preload

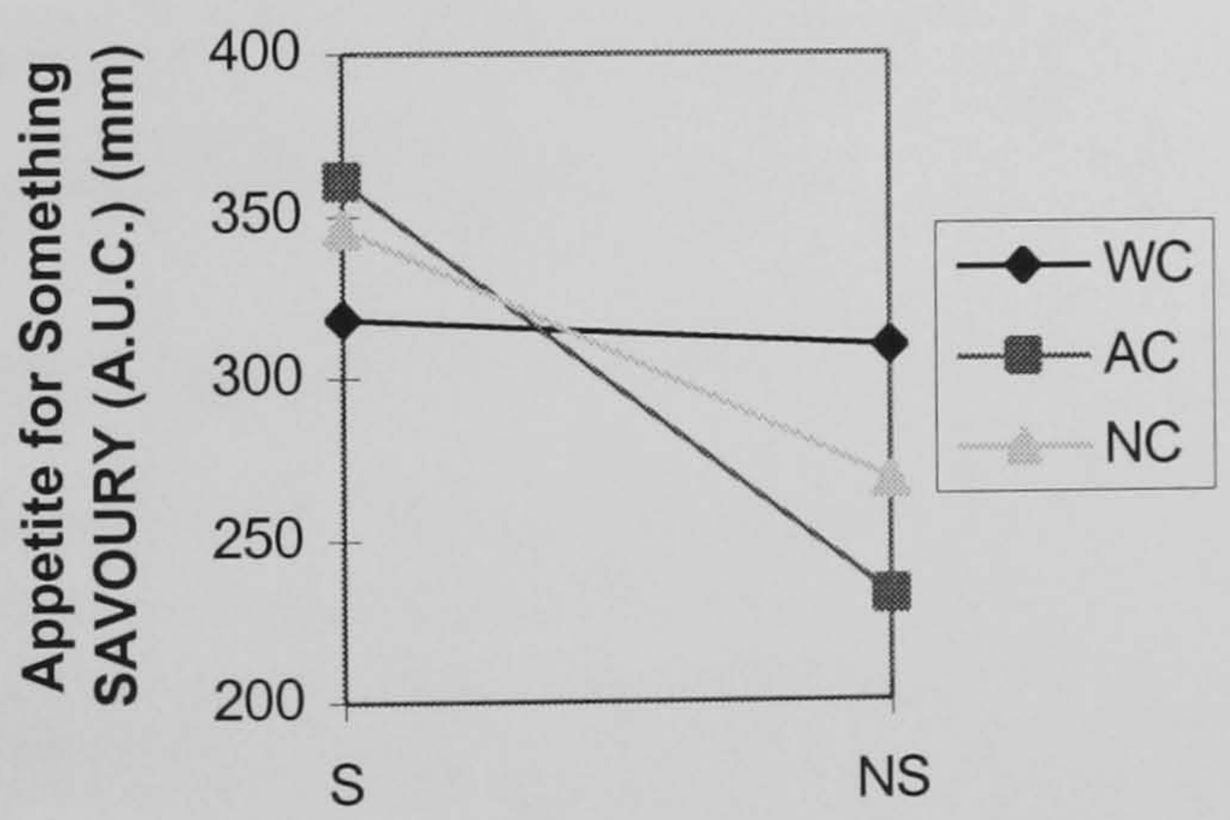


Figure 9.11: Interaction Graph for Subjective Measures of Appetite for a MEAL - All Participants - Consumer by Preload

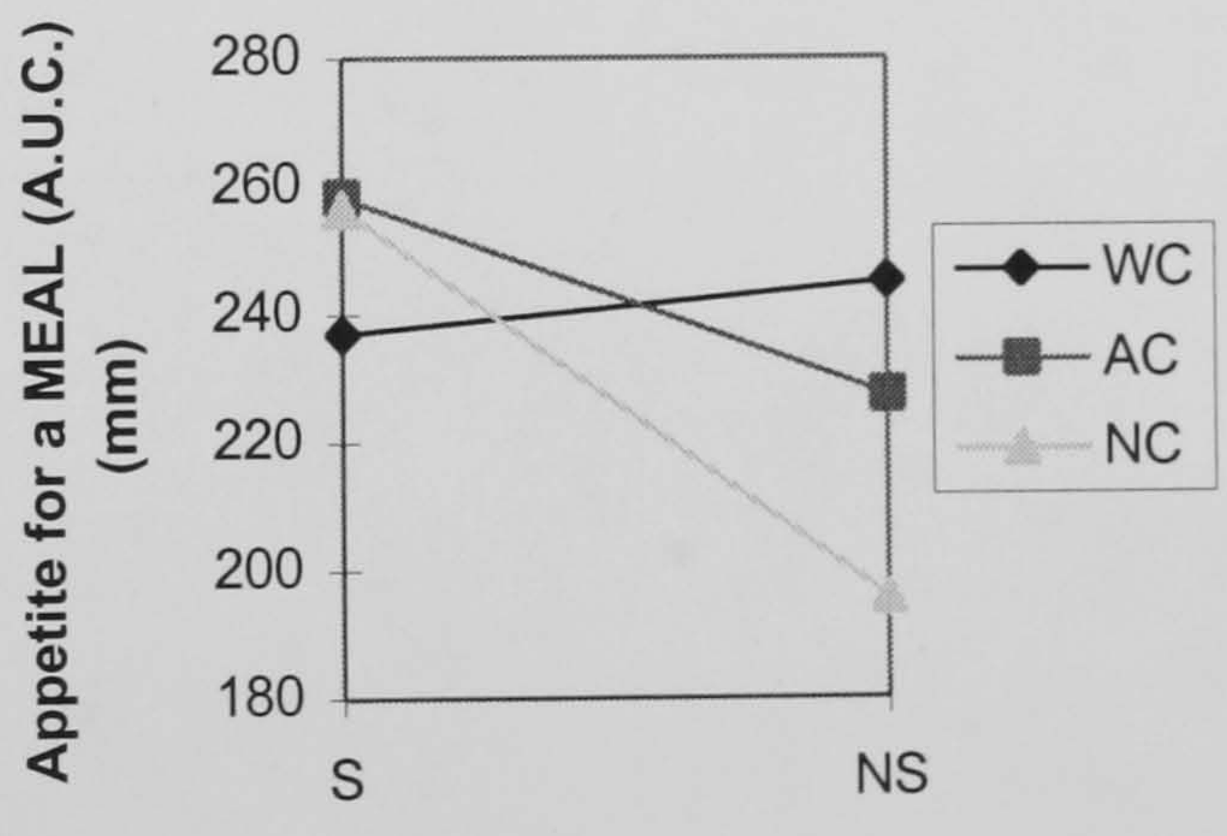


Figure 9.12: Temporal Profile for Subjective Measures of Appetite for Something SAVOURY - All Participants - Preload by Time

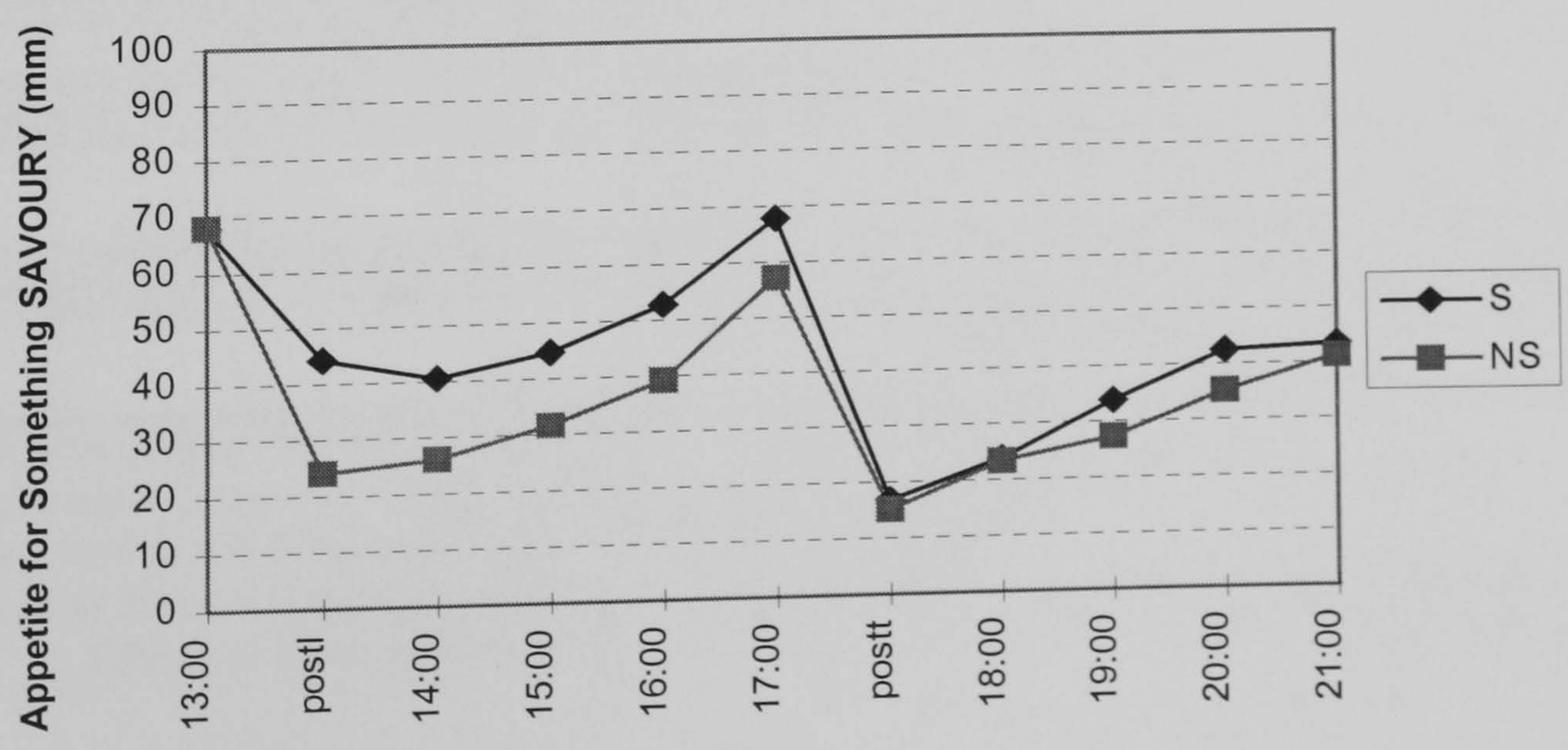
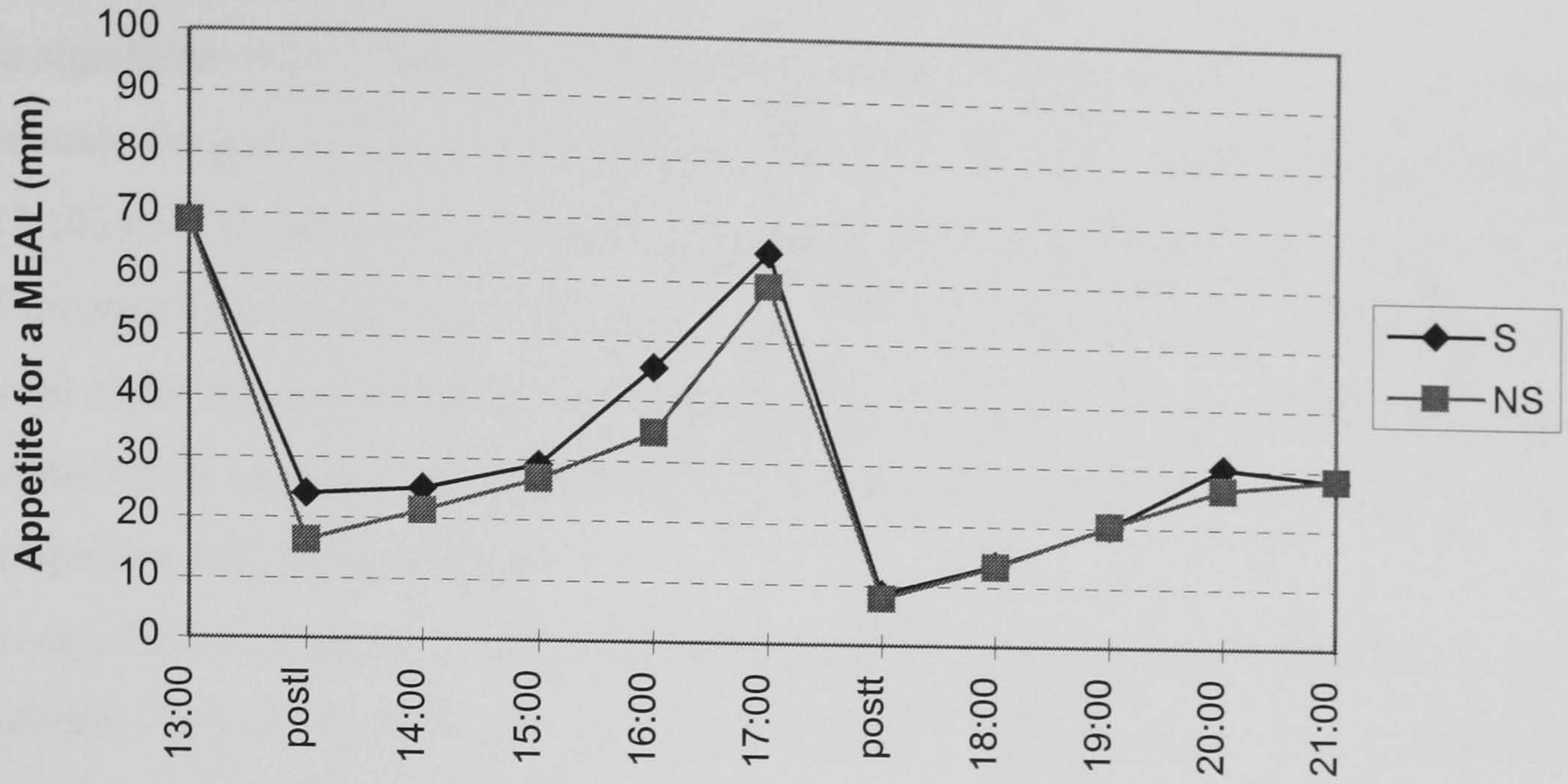


Figure 9.13: Temporal Profile for Subjective Measures of Appetite for a MEAL - All Participants - Preload by Time



Summary: All important significant results in the subjective measures of appetite, in all participants are summarized in Table 9.4. All other systematic significant interactions found are reported only in the text.

Table 9.4: All Important Significant Results in Subjective Measures of Appetite - All Participants

	Gender	Consumer	G x C	Preload	C x P	Time
Subjective Measures of Hunger - Hunger (H.), Desire to Eat (D.E.), Fullness (F.), Prospective Consumption (P.C.)						
H.					WC, AC: S = NS NC: S > NS	T
D.E.	M > F				WC, AC: S = NS NC: S > NS	T
F.						T, PT
P.C.						T
Subjective Measures of Thirst - Thirst (T.), Desire to Drink (D.D.)						
T.		AC > WC = NC	M: AC = WC = NC F: AC > WC = NC	S < NS		T
D.D.		AC > WC = NC	M: AC = WC = NC F: AC > WC = NC			T
Subjective Measures of Appetite for Something Sweet						
		AC = NC > WC		S < NS		T, PT
Subjective Measures of Appetite for Something Savoury						
				S > NS	WC: S = NS AC, NC: S > NS	T, PT
Subjective Measures of Appetite for a Meal						
				S > NS	WC, AC: S = NS NC: S > NS	T, PT

Effects of Gender: M = Male Participants, F = Female Participants,
Effects of Consumer: WC = WC Consumers, NC = NC Consumers, AC = AC Consumers,
Effects of Preload: S = Sweet Lunch, NS = Non-Sweet Lunch,
Effects of Time: T = Normal Effects of Time on Appetite, P x T = Preload x Time Interaction - Effects of Time found only between lunch and tea. No effects were found following tea.

9.3.3.2. Male Participants

Subjective Measures of Hunger:

No significant differences were found between consumers (largest $F(2,18)=1.06$, $p=0.37$) or preloads (largest $F(1,21)=2.14$, $p=0.16$). Consistent effects of time were found (smallest $F(5,105)=90.66$, $p<0.001$). A significant preload by time interaction was found in the scale of prospective consumption ($F(5,105)=2.46$, $p=0.04$). Male participants reported an ability to eat more following the sweet lunch compared to the non-sweet lunch, in the afternoon, but not in the evening. No other interactions were found (largest $F(5,105)=3.15$, $p=0.06$).

Subjective Measures of Thirst:

No significant differences were found between consumers (largest $F(2,18)=1.74$, $p=0.20$) or preloads (largest $F(1,21)=1.26$, $p=0.28$). Consistent significant effects of time were found (smallest $F(5,105)=28.38$, $p<0.001$). A significant interaction was found between preload and time in the scale of desire to drink ($F(5,105)=2.52$, $p=0.04$). Male participants reported a higher desire to drink following the non-sweet lunch than following the sweet lunch, throughout the afternoon. No differences were found in the evening. No other interactions were found (largest $F(5,105)=2.05$, $p=0.08$).

Subjective Measures of Appetite for Something Sweet:

No significant differences were found between consumers ($F(2,18)=0.44$, $p=0.65$). Significant differences were found between preloads ($F(1,21)=13.81$, $p=0.001$). Male participants reported a lower appetite for something sweet following the sweet lunch than following the non-sweet lunch. Significant effects of time were found ($F(5,105)=20.27$, $p<0.001$). A significant preload by time interaction was found ($F(5,105)=6.53$, $p<0.001$). Male participants demonstrated a lower appetite for something sweet following the sweet lunch than following the non-sweet lunch in the afternoon, but no differences were found in the evening. No other interactions were found (largest $F(10,105)=1.56$, $p=0.13$).

Subjective Measures of Appetite for Something Savoury:

No significant differences were found between consumers ($F(2,18)=0.01$, $p=0.99$). Significant differences were found between preloads ($F(1,21)=8.98$, $p=0.01$). Male participants reported a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch. Significant effects of time were found ($F(5,105)=73.17$, $p<0.001$). A significant preload by time interaction was found ($F(5,105)=5.57$, $p<0.001$). Male participants demonstrated a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch throughout the afternoon, but not in the evening. No other interactions were found (largest $F(2,21)=0.96$, $p=0.40$).

Subjective Measures of Appetite for a Meal:

No significant differences were found between consumers ($F(2,18)=0.95$, $p=0.41$) or preloads ($F(1,21)=2.58$, $p=0.12$). Effects of time were found ($F(5,105)=115.56$, $p<0.001$). No interactions were found (largest $F(10,105)=1.55$, $p=0.13$).

Summary: In male participants, no differences were found between consumers in any of the subjective measures of appetite. Significant differences were found between preloads in measures of Appetite for Something Sweet (S < NS), and Appetite for Something Savoury (S > NS). Significant effects of time were found in all scales. Significant preload by time interactions were found in scales of Prospective Consumption (S > NS), Desire to Drink (S < NS), Appetite for Something Sweet (S < NS) and Appetite for Something Savoury (S > NS). Difference between preloads were found in the afternoon only.

9.3.3.3. Female Participants

Subjective Measures of Hunger:

No significant differences were found between consumers (largest $F(2,21)=2.35$, $p=0.12$). Significant differences were found between preloads in the scale of desire to eat ($F(1,21)=8.35$, $p=0.01$) (see Figure 9.14). Female participants reported a higher desire to eat following the sweet lunch than following the non-sweet lunch. Consistent effects of time were found (smallest $F(10,210)=53.20$, $p<0.001$). Significant interactions of consumer by preload by time were found in scales of desire to eat ($F(20,210)=2.15$, $p=0.004$) (see Figure 9.15) and prospective consumption ($F(20,210)=1.94$, $p=0.01$). WC consumers reported a similar desire to eat and prospective consumption following the sweet and the non-sweet lunch, throughout the day. NC consumers reported a higher desire to eat and prospective consumption following the sweet lunch compared to the non-sweet lunch in the afternoon only. AC consumers reported an increased desire to eat and prospective consumption following the sweet lunch compared to the non-sweet lunch throughout the day. No other systematic interactions were found.

Figure 9.14: Temporal Profile for Subjective Measures of DESIRE TO EAT - Female Participants - Preload by Time

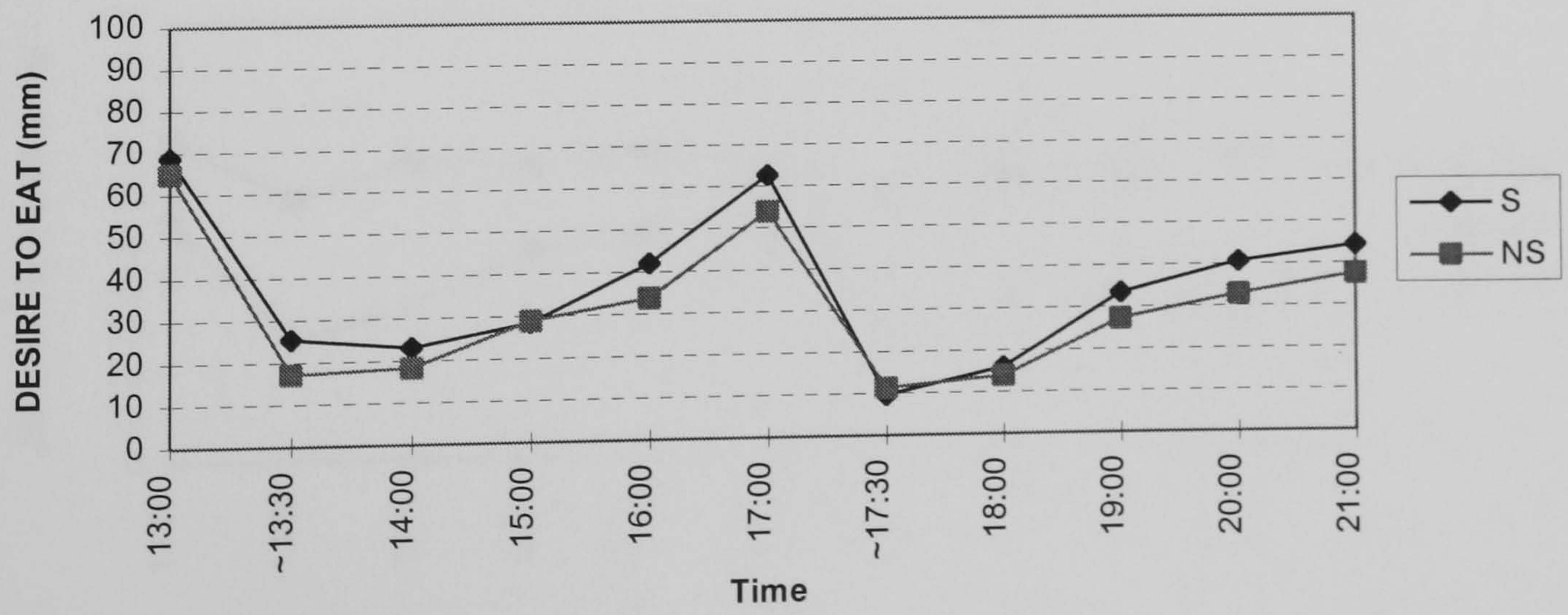
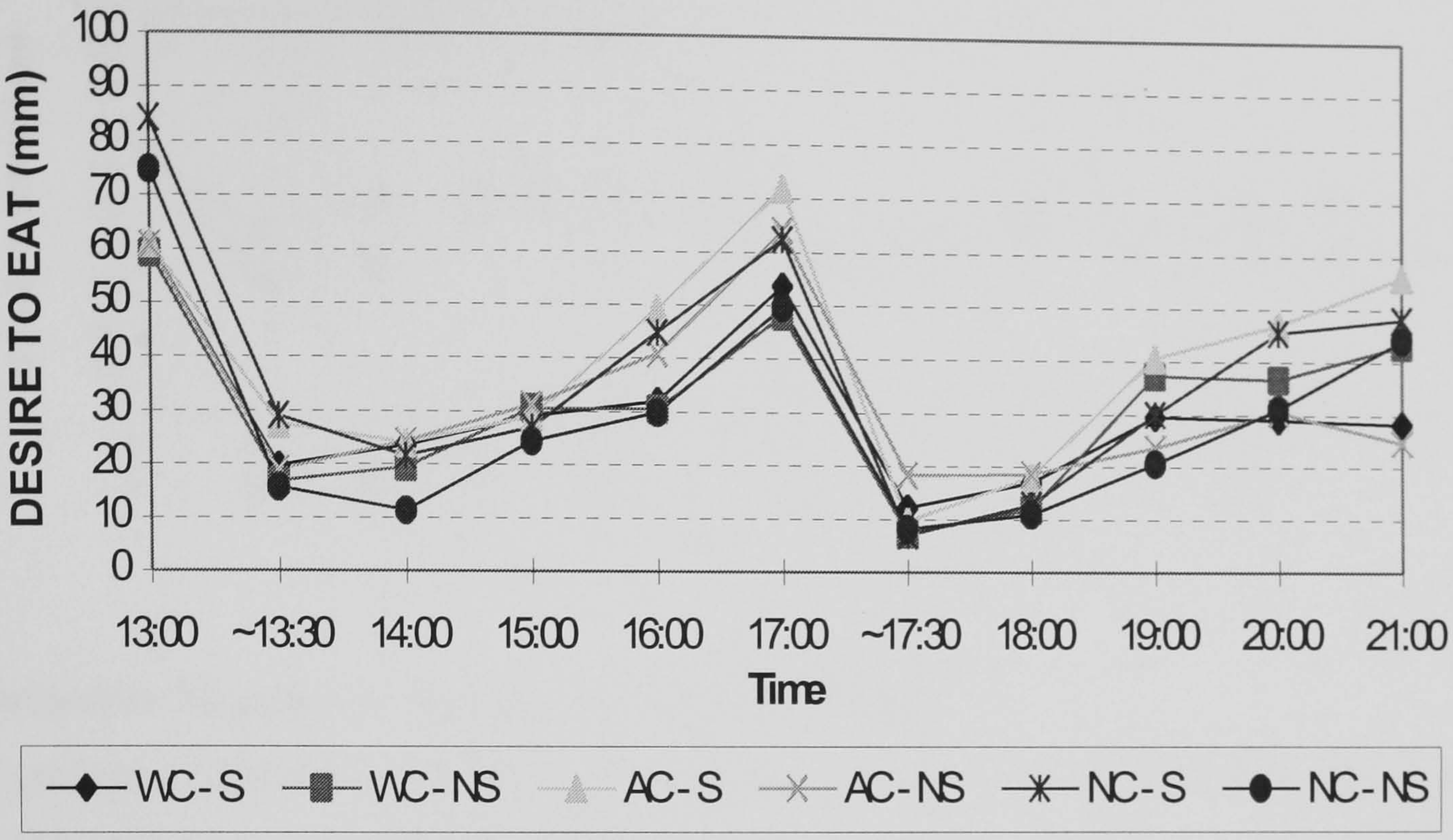


Figure 9.15: Temporal Profile for Subjective Measures of DESIRE TO EAT - Female Participants - Consumer by Preload by Time



Subjective Measures of Thirst:

Significant differences were found between consumers (smallest $F(2,21)=11.90$, $p<0.001$) (see Figure 9.16). AC consumers reported higher levels of thirst than WC consumers (thirst $t(14)=-4.62$, $p<0.001$; desire to drink $t(14)=-4.46$, $p=0.001$) and NC consumers (thirst $t(14)=-6.12$, $p<0.001$; desire to drink $t(14)=-5.28$, $p<0.001$). No differences were found between WC and NC consumers (thirst $t(14)=-0.19$, $p=0.85$; desire to drink $t(14)=0.12$, $p=0.90$). Significant differences were found between preloads (smallest $F(1,21)=5.95$, $p=0.02$) (see Figure 9.17). Female participants reported a higher thirst and desire to eat following the non-sweet lunch than following the sweet lunch. Significant effects of time were found (smallest $F(1,21)=8.63$, $p<0.001$). No significant interactions were found (largest $F(10,210)=1.50$, $p=0.08$).

Figure 9.16: Temporal Profile for Subjective Measures of DESIRE TO DRINK - Female Participants - Consumer by Time

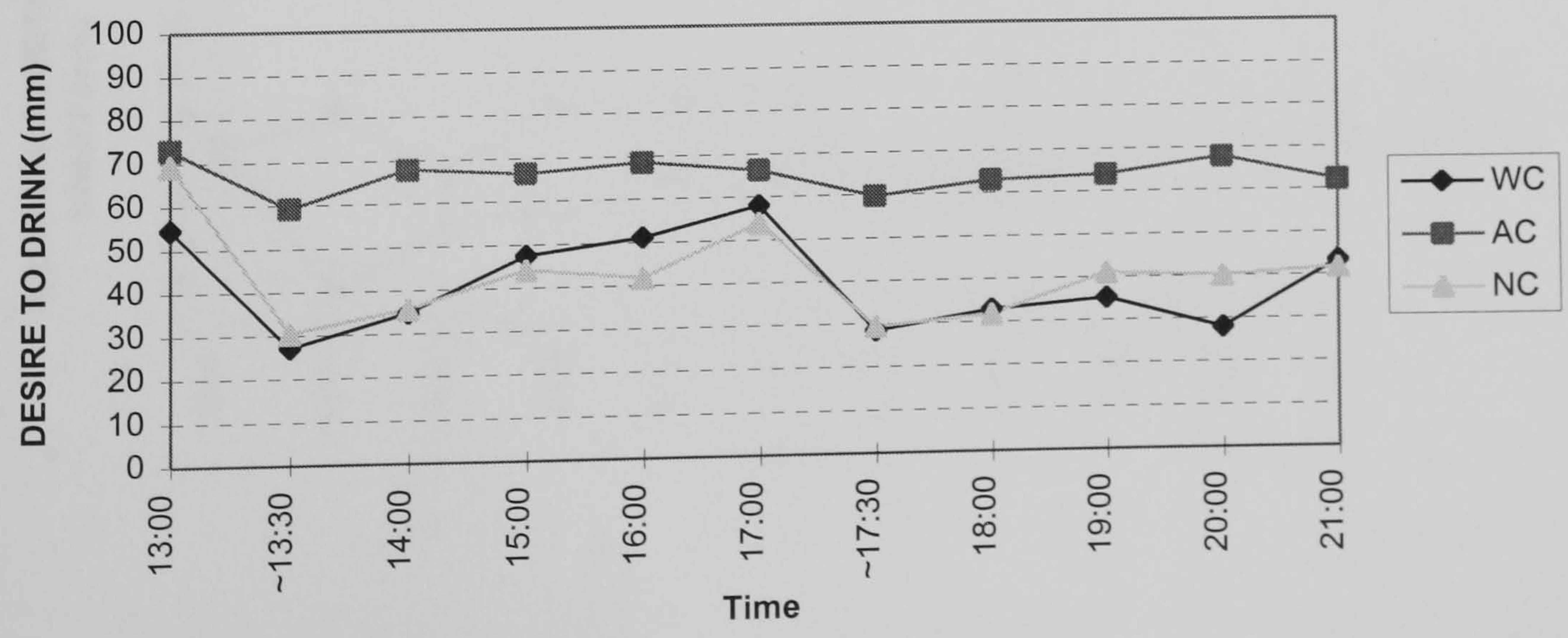
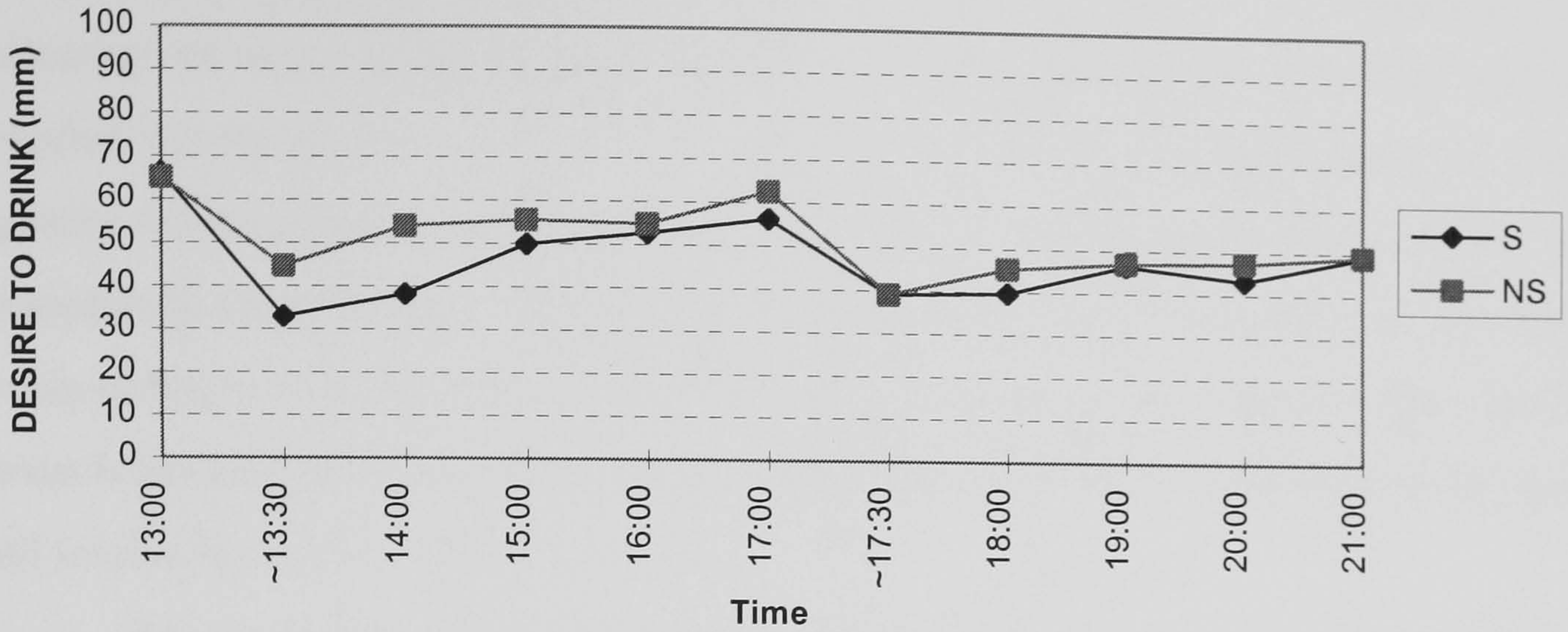


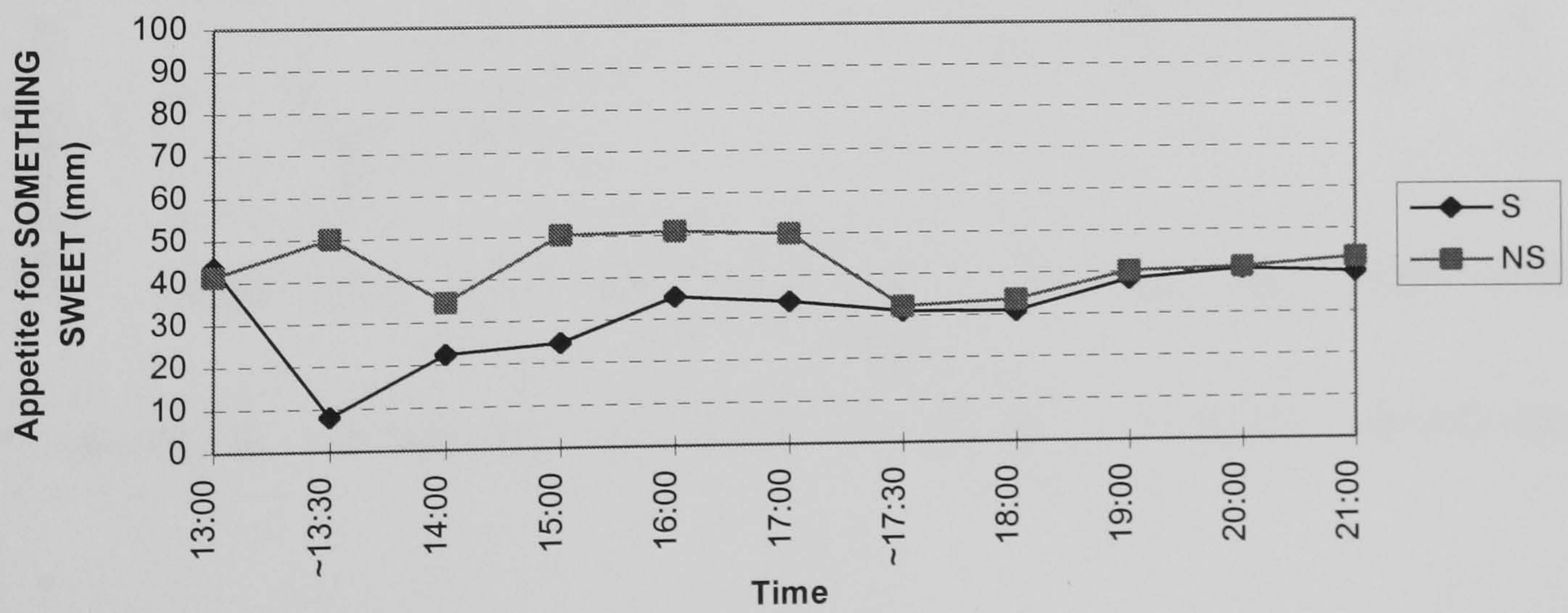
Figure 9.17: Temporal Profile for Subjective Measures of DESIRE TO DRINK - Female Participants - Preload by Time



Subjective Measures of Appetite for Something Sweet:

Significant differences were found between consumers (F(2,21)=4.17, p=0.03) (see Figure 9.18). WC consumers reported a lower appetite for something sweet than AC consumers (t(14)=-2.61, p=0.02) and demonstrated a similar trend compared to NC consumers (t(14)=1.86, p=0.08). No differences were found between AC and NC consumers (t(14)=-1.33, p=0.20). Significant differences were found between preloads (F(1,21)=22.02, p<0.001) (see Figure 9.18). Female participants reported a lower appetite for something sweet following the sweet lunch than following the non-sweet lunch. Significant effects of time were found (F(10,210)=4.33, p<0.001). Significant interactions were found between preload and time (F(10,210)=9.97, p<0.001) (see Figure 9.18). Female participants reported a lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch, throughout the afternoon. No differences were found in the evening.

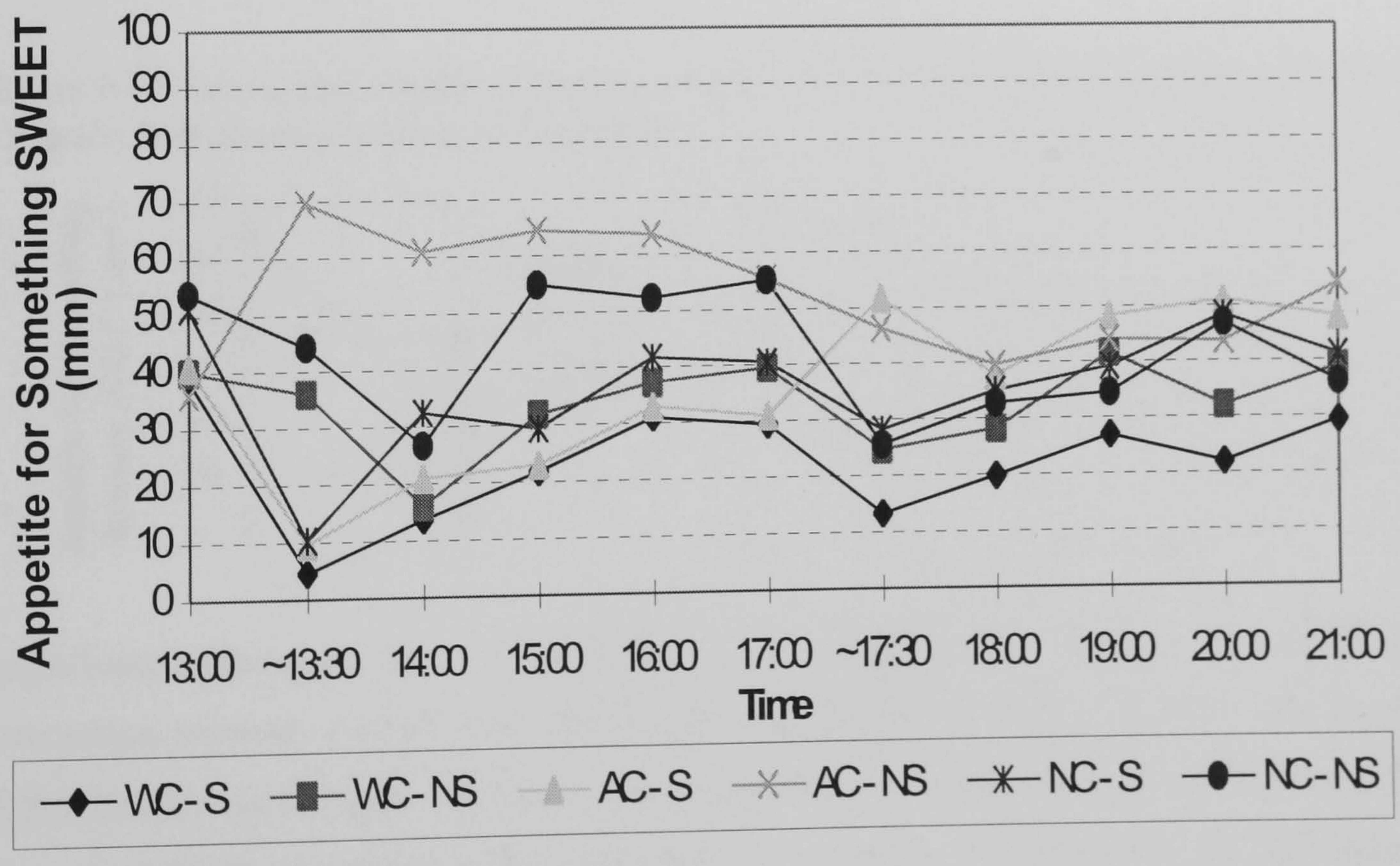
Figure 9.18: Temporal Profile for Subjective Measures of APPETITE FOR SOMETHING SWEET - Female Participants - Preload by Time



Significant interactions were also found in consumer by preload by time (F(20,210)=2.51, p<0.001) (see Figure 9.19). WC consumers reported a lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch immediately after lunch, but reported similar levels of appetite for the rest of the day. NC consumers reported a lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch immediately after lunch, a slightly lower appetite for the rest of the afternoon, and similar levels of appetite in the evening. AC consumers reported a lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch throughout the afternoon, and similar levels of appetite in the evening.

AC consumers also reported an increase in appetite for something sweet following the non-sweet lunch compared to baseline measures (i.e. 13:00 - pre-lunch) (t(7)=-4.98, p=0.002), and this increase in appetite lasted throughout the afternoon (smallest t(7)=-2.39, p=0.05). NC consumers reported a decrease in appetite for something sweet compared to baseline measures (t(7)=2.94, p=0.02) only 30 min. after lunch. WC consumers reported only a trend toward a decrease in appetite (t(7)=1.95, p=0.09), also 30 min. after the meal. Following the sweet lunch all consumers reported an immediate decrease in appetite, gradually returning to pre-lunch levels.

Figure 9.19: Temporal Profile for Subjective Measures of APPETITE FOR SOMETHING SWEET - Female Participants - Consumer by Preload by Time



Subjective Measures of Appetite for Something Savoury:

No significant differences were found between consumers ($F(2,21)=0.05$, $p=0.95$). Significant differences were found between preloads ($F(1,21)=24.28$, $p<0.001$) (see Figure 9.20). Female participants reported a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch. A significant consumer by preload interaction was found ($F(2,21)=7.41$, $p=0.004$) (see Figure 9.21). WC consumers reported similar levels of appetite following both lunches ($t(15)=0.43$, $p=0.68$), AC and NC consumers reported lower levels of appetite for something savoury following the non-sweet lunch than following the sweet lunch (AC $t(15)=-5.59$, $p=0.001$; NC $t(15)=-2.78$, $p=0.03$).

Figure 9.20: Temporal Profile for Subjective Measures of APPETITE FOR SOMETHING SAVOURY - Female Participants - Preload by Time

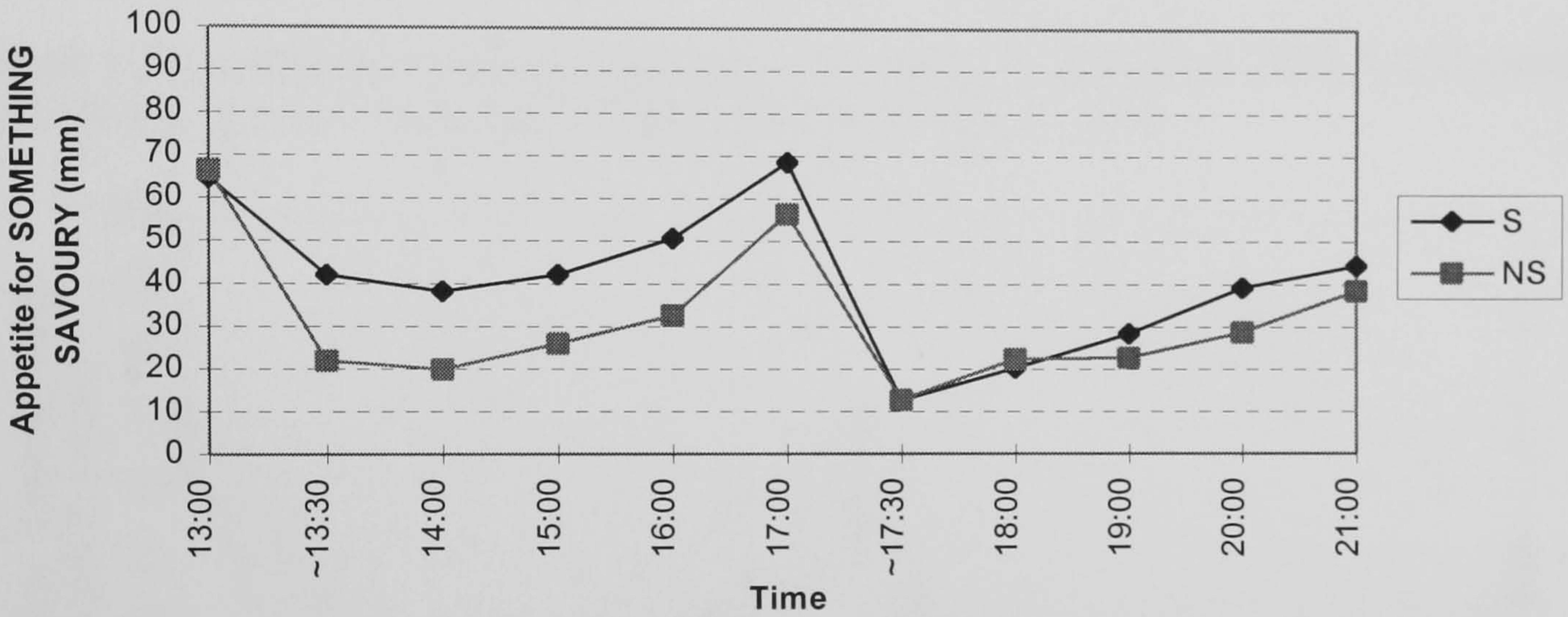
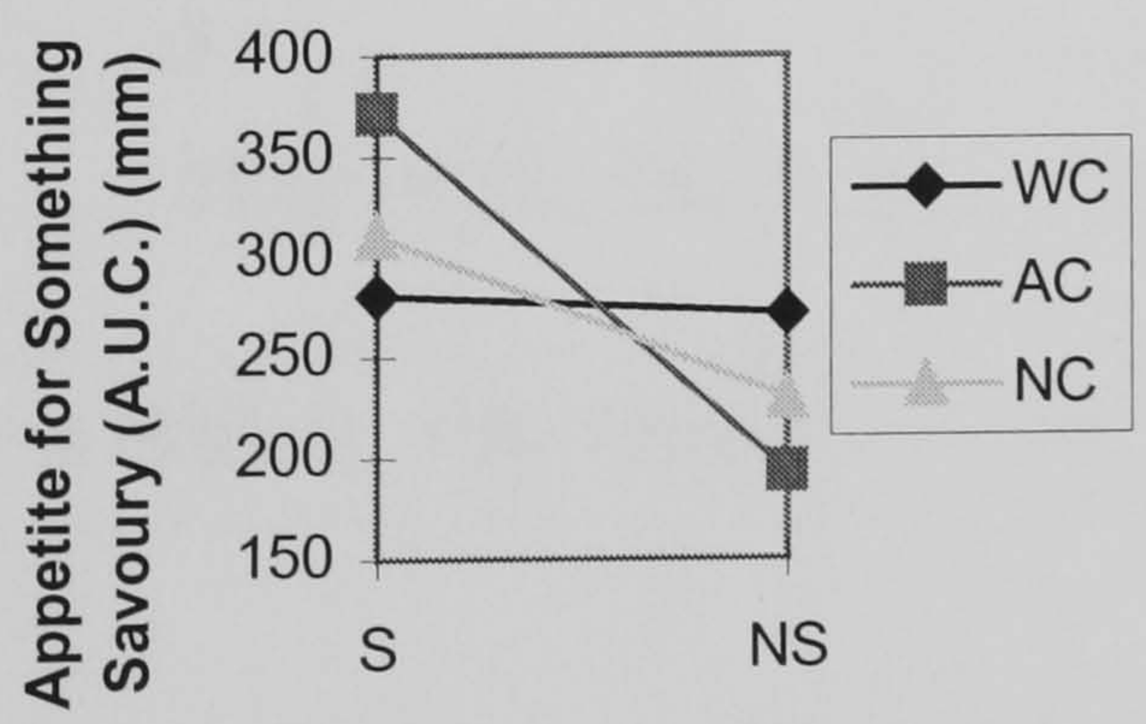


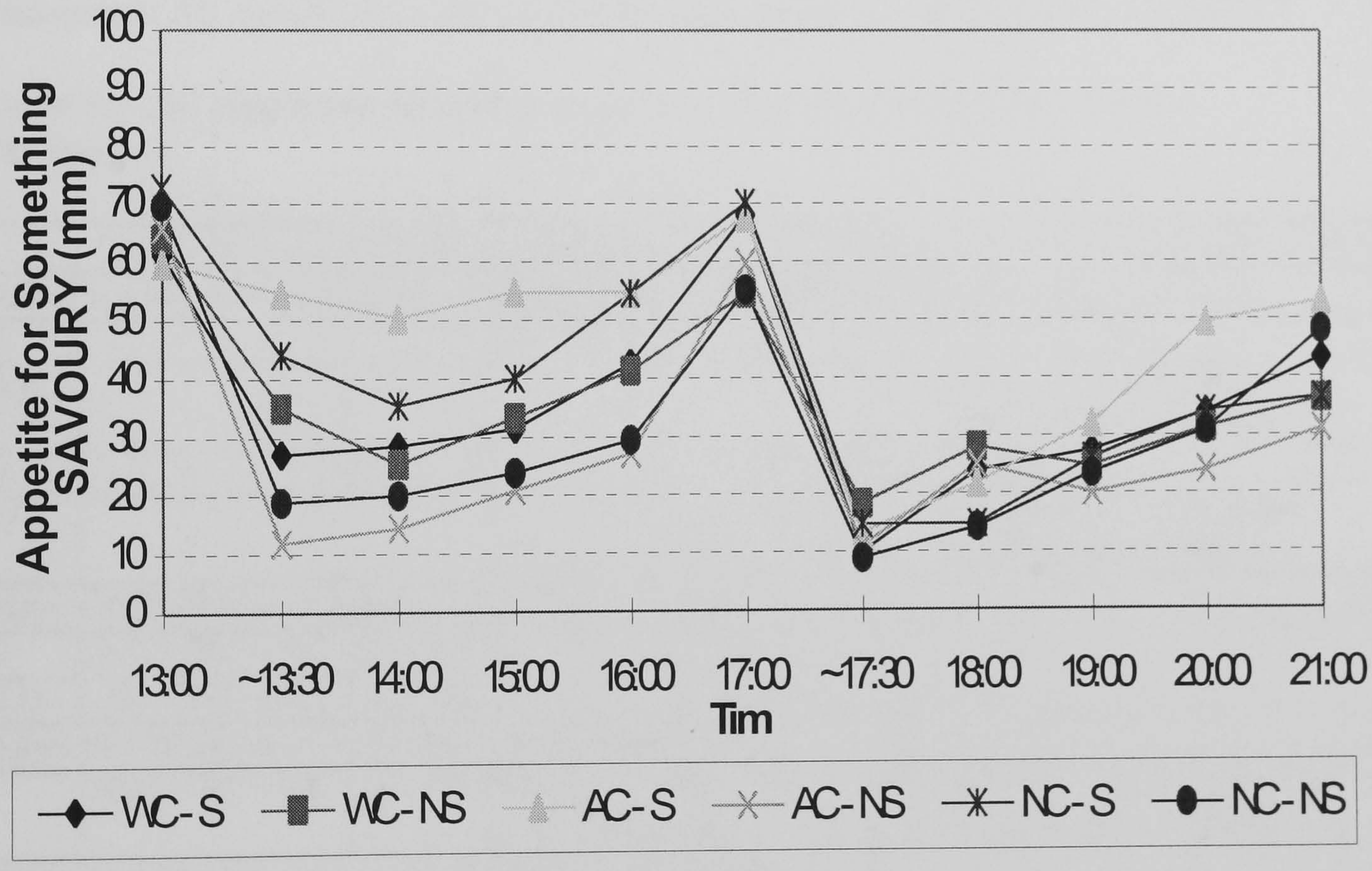
Figure 9.21: Interaction Graph for Subjective Measures of Appetite for Something Savoury - Female Participants - Consumer by Preload



Significant effects of time were found ($F(10, 210)=38.39$, $p<0.001$). A significant interaction between preload and time was found ($F(10,210)=5.19$, $p<0.001$) (see Figure 9.20). Female participants reported a lower appetite for something savoury following the non-sweet lunch compared to the sweet lunch, throughout the afternoon. No differences were found in the evening. A significant interaction between consumer and preload and time was also found ($F(20,210)=2.94$, $p<0.001$) (see Figure 9.22). WC consumers reported similar levels of appetite for something savoury following both lunches, throughout the day. NC consumers reported a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch, throughout the afternoon, but not in the evening. AC consumers reported a lower appetite for something savoury following the non-sweet lunch compared to the sweet lunch throughout the whole day.

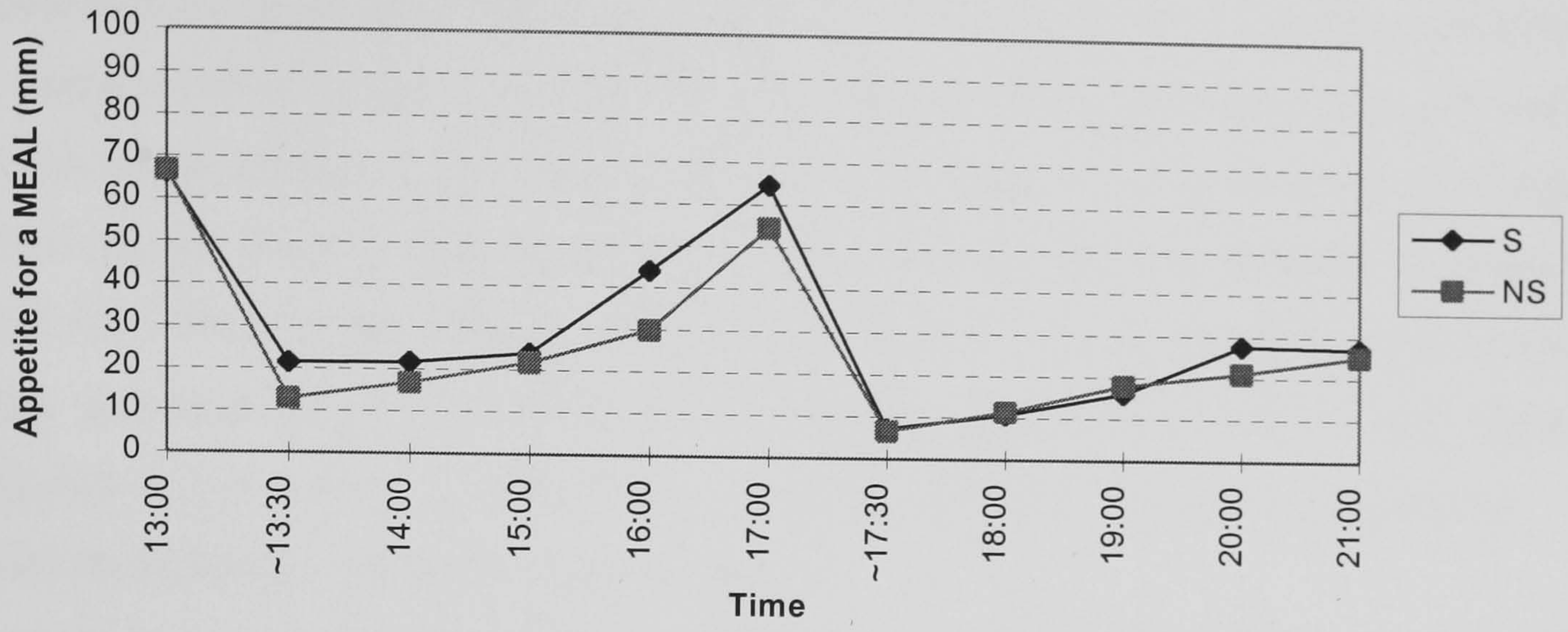
Compared to pre-lunch measures, all participants reported a decrease in appetite for something savoury following the non-sweet lunch (WC smallest t(7)=3.07, p=0.02; AC smallest t(7)=3.60, p=0.01; NC smallest t(7)=4.61, p=0.002). WC and NC consumers also reported a decrease in appetite following the sweet lunch, although effects only lasted throughout the whole afternoon in WC consumers (smallest t(7)=2.85, p=0.03). AC consumers reported similar levels of appetite for something savoury pre- and post- sweet lunch (largest t(7)=1.06, p=0.33).

Figure 9.22: Temporal Profile for Subjective Measures of APPETITE FOR SOMETHING SAVOURY - Female Participants - Consumer by Preload by Time



Subjective Measures of Appetite for a Meal: No significant differences were found between consumers (F(2,21)=0.24, p=0.79). Significant differences were found between preloads (F(1,21)=6.41, p=0.02) (see Figure 9.23). Female participants reported a lower appetite for a meal following the non-sweet lunch than the sweet lunch. Significant effects of time were found (F(20,210)=63.56, p<0.001). A preload by time interaction was found (F(10,210)=2.34, p=0.01) (see Figure 9.23). Female participants reported a lower appetite for a meal following the non-sweet lunch compared to the sweet lunch, throughout the afternoon. No differences were found in the evening. No other interactions were found (largest $F(2,21)=1.48$, $p=0.25$).

Figure 9.23: Temporal Profile for Subjective Measures of APPETITE FOR A MEAL - Female Participants - Preload by Time



Summary: All significant results in female participants are summarized in Table 9.5

Table 9.5: All Significant Results in Subjective Measures of Appetite - Female Participants

	Consumer	P'load	Consumer x Preload	Time	Consumer x Preload x Time #
Subjective Measures of Hunger - Hunger, Desire to Eat, Fullness, Prospective Consumption					
H.				T	
D.E		S > NS		T	WC: S = NS all day NC, AC: S > NS all day
F.				T	
P.C.				T	WC, NC: S = NS all day AC: S > NS all day
Subjective Measures of Thirst - Thirst, Desire to Drink					
T	AC > WC = NC	S < NS		T	
D.D.	AC > WC = NC	S < NS		T	
Subjective Measures of Appetite for Something Sweet					
	WC < AC = NC	S < NS	WC, NC: PNS > NS AC: PNS < NS	T, PT	WC: S < NS post-lunch only NC, AC: S < NS afternoon
Subjective Measures of Appetite for Something Savoury					
		S > NS	WC: S = NS AC, NC: S > NS WC, NC: PS > S AC: PS = S	T, PT	WC: S = NS all day NC: S > NS afternoon AC: S > NS all day
Subjective Measures of Appetite for a Meal					
		S > NS		T, PT	

Effects of Consumer: WC = WC Consumers, NC = NC Consumers, AC = AC Consumers,
Effects of Preload: S = Sweet Lunch, NS = Non-Sweet Lunch, PS = Pre-Sweet Lunch, PNS = Pre-Non-Sweet Lunch
Effects of Time: T = Normal Effects of Time on Appetite, P x T = Preload x Time Interaction - Effects of Time found only between lunch and tea. No effects were found following tea.
No other systematic significant interactions were found.

9.3.4. BEHAVIOURAL MEASURES OF APPETITE

9.3.4.1. All Participants

Test Meal Intake - Weight Consumed (gram.):

In Individual and Cumulative Test Meal Intake, significant differences were found between genders in tea intake (F(1,39)=5.72, p=0.02), after tea (F(1,39)=4.22, p=0.05) and followed a similar trend at the end of the day (F(1,39)=3.87, p=0.06). Males consumed more weight of food than females. No significant differences were found between consumers (largest F(2,41)=0.43, p=0.65). Significant differences were found between preloads in tea intake (F(1,42)=3.99, p=0.05). All participants consumed more weight of food following the sweet than following the non-sweet lunch. No significant interactions were found (largest F(2,42)=2.82, p=0.07). Test Meal Intake - Weight consumed is shown in Appendix 9.6.

Test Meal Intake - Energy Consumed (kcal.):

In Individual and Cumulative Test Meal Intake, no significant differences were found between genders (largest F(1,39)=3.31, p=0.08), consumers (largest F(2,39)=0.36, p=0.70) or preloads (largest F(1,42)=2.51, p=0.12). No significant interactions were found (largest F(2,42)=2.08, p=0.14). Test Meal Intake - Energy Consumed is shown in Appendix 9.7.

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In Individual and Cumulative Test Meal Intake, in proportion of energy consumed from carbohydrate, significant differences were found between genders in tea intake (F(1,39)=7.55, p=0.01). Males consumed a smaller proportion of energy from carbohydrate than females. No differences were found between consumers (largest F(2,39)=1.16, p=0.33). Significant differences were found between preloads following tea (F(1,42)=45.51, p<0.001) and at the end of the day (F(34.76, p<0.001). All participants consumed more energy from carbohydrate following (and including) the sweet lunch compared to the non-sweet lunch. No systematic interactions were found.

In proportion of energy consumed from fat, significant differences were found between genders in tea intake (F(1,39)=16.06, p<0.001) and following tea intake (F(1,39)=5.69, p=0.02). Males consumed a greater proportion of energy from fat than females. No differences were found between consumers (largest F(2,39)=1.27, p=0.29) or preloads (F(1,42)=2.62, p=0.11). No interactions were found (largest F(2,41)=2.43, p=0.10).

In proportion of energy consumed from protein, no significant differences were found between genders (largest F(1,39)=0.72, p=0.40) or consumers (largest F(2,39)=2.34, p=0.11). Significant differences were found between preloads following tea (F91,42)=121.23, p<0.001) and at the end of the day (F(1,42)=234.00 p<0.001). All participants consumed more energy from protein following (and including) the non-sweet lunch compared to the sweet lunch. No systematic interactions were found. Test Meal Intake - Proportions of All Macronutrients Consumed is shown in Appendix 9.8.

Summary:

Significant differences were found between genders - males consumed more weight of food, less energy from carbohydrate and more energy from fat than females. No significant differences were found between consumers. Significant differences were found between preloads - participants consumed more weight following the sweet lunch, and more energy from carbohydrate and less energy from protein following and including the sweet lunch compared to the non-sweet lunch. No systematic interactions were found.

9.3.4.2. Male Participants

Test Meal Intake: Weight Consumed (gram.):

In Individual and Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(2,18)=0.16$, $p=0.85$) or preloads (largest $F(1,21)=0.64$, $p=0.43$). Significant (consumer by preload) interactions were found in tea intake ($F(2,21)=6.20$, $p=0.007$), and at the end of the day ($F(2,21)=6.29$, $p=0.007$) (see Figures 9.24 and 9.25). WC consumers consumed <u>more</u> weight of food following the non-sweet meal than following the sweet meal (tea $t(7)=2.93$, $p=0.02$; end of day $t(7)=3.99$, $p=0.005$), AC and NC consumers consumed a <u>similar</u> weight of food following the sweet and the non-sweet lunch (tea AC $t(7)=-1.96$, $p=0.09$; NC $t(7)=-1.26$, $p=0.25$; end of day AC $t(7)=-1.88$, $p=0.10$; NC $t(7)=-0.36$, $p=0.71$). Similar trends were also found on analysis of the interaction following tea intake ($F(2,21)=3.40$, $p=0.05$).

Figure 9.24: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - Male Participants - Tea Intake - Consumer by Preload

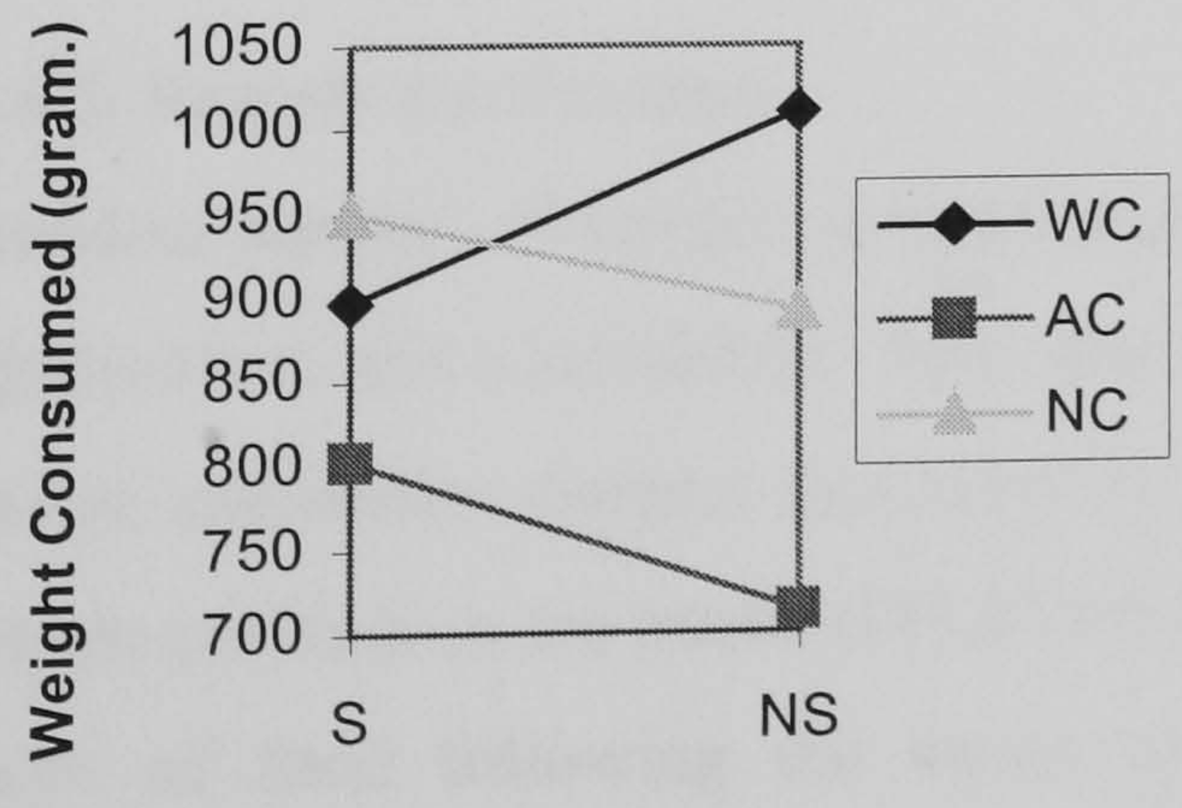
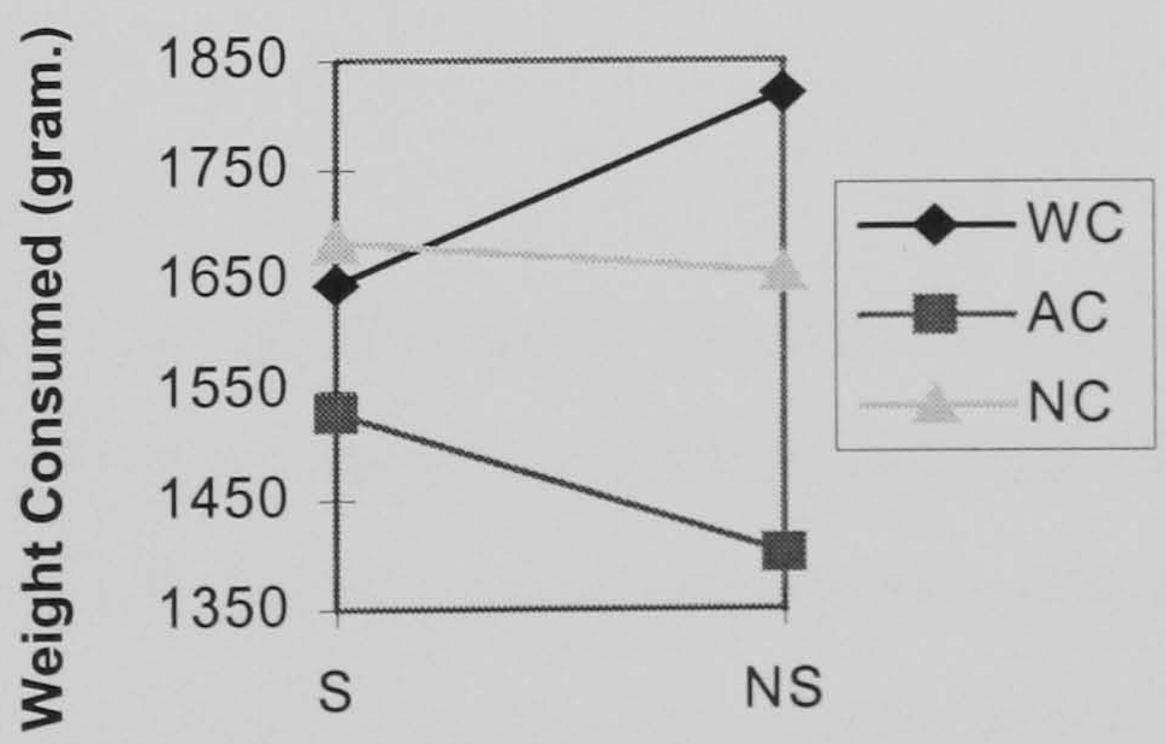


Figure 9.25: Interaction Graph for Test Meal Intake - Weight Consumed (gram.) - Male Participants - End of the Day Intake - Consumer By Preload



Test Meal Intake - Energy Consumed (kcal.):

In Individual and Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(2,18)=0.09$, $p=0.92$) or preloads (largest $F(1,21)=0.89$, $p=0.36$). No interactions were found (largest $F(2,21)=2.51$, $p=0.11$).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In Individual and Cumulative Test Meal Intake, in proportion of energy consumed from carbohydrate, no significant differences were found between consumers (largest $F(2,18)=1.97$, $p=0.17$). Significant differences were found between preloads following tea ($F(1,21)=35.96$, $p<0.001$) and at the end of the day (largest $F(1,21)=10.05$, $p=0.01$). Male participants consumed more energy from carbohydrate following (and including) the sweet lunch compared to the non-sweet lunch. No interactions were found (largest $F(2,21)=1.49$, $p=0.25$). In proportion of energy consumed from fat, no significant differences were found between consumers (largest $F(2,18)=1.81$, $p=0.19$) or preloads (largest $F(1,21)=0.63$, $p=0.44$). No interactions were found (largest $F(2,21)=2.08$, $p=0.15$). In proportion of energy consumed from protein, no significant differences were found between consumers (largest $F(2,18)=1.69$, $p=0.21$). Significant differences were found between preloads following tea ($F(1,21)=115.70$, $p<0.001$) and at the end of the day ($F(1,21)=73.96$, $p<0.001$). Males consumed more energy from protein following (and including) the non-sweet lunch compared to the sweet lunch. No interactions were found (largest $F(2,21)=1.10$, $p=0.35$).

Summary:

No significant differences were found between consumers. Significant differences were found between preloads - male participants consumed more energy from carbohydrate and less energy from protein following the sweet lunch compared to the non-sweet lunch. Significant interactions were found - male WC consumers consumed more weight following the non-sweet meal than following the sweet meal, male AC and NC consumers consumed similar amounts following both lunches.

9.3.4.3. Female Participants

Test Meal Intake - Weight consumed (gram.):

In Individual and Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(2,21)=2.23$, $p=0.13$). One significant difference was found between preloads in tea intake ($F(1,21)=5.62$, $p=0.03$). Female participants consumed more weight of food following the sweet lunch than following the non-sweet lunch. No significant interactions were found (largest $F(2,21)=2.68$, $p=0.09$).

Test Meal Intake - Energy Consumed (kcal.):

In Individual and Cumulative Test Meal Intake, no significant differences were found between consumers (largest $F(2,21)=2.23$, $p=0.13$) or preloads (largest $F(1,21)=2.11$, $p=0.16$). No interactions were found (largest $F(2,21)=1.58$, $p=0.23$).

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

In Individual and Cumulative Test Meal Intake, in proportion of energy consumed from carbohydrate, no significant differences were found between consumers (largest $F(2,21)=3.06$, $p=0.07$). Significant differences were found between preloads following tea ($F(1,21)=16.22$, $p=0.001$) and at the end of the day ($F(1,21)=26.08$, $p<0.001$). Female participants consumed more energy from carbohydrate following (and including) the sweet lunch compared to the non-sweet lunch. No interactions were found (largest $F(2,21)=0.59$, $p=0.57$). In proportion of energy consumed from fat, no significant differences were found between consumers (largest $F(2,21)=3.01$, $p=0.07$) or preloads (largest $F(1,21)=2.17$, $p=0.16$). No interactions were found (largest $F(2,21)=0.51$, $p=0.61$). In proportion of energy consumed from protein, no significant differences were found between consumers (largest $F(2,21)=1.54$, $p=0.24$). Significant differences were found between preloads following tea ($F(1,21)=32.65$, $p<0.001$) and at the end of the day ($F(1,21)=224.87$, $p<0.001$). Female participants consumed more energy from protein following (and including) the non-sweet lunch compared to the sweet lunch. No interactions were found (largest $F(2,21)=0.26$, $p=0.77$).

Summary:

No significant differences were found between consumers. Significant differences were found between preloads - female participants consumed more weight, more energy from carbohydrate and less energy from protein following the sweet lunch compared to the non-sweet lunch. No significant interactions were found.

9.4. DISCUSSION

Analysing all participants together, significant differences were found in this study, between genders, consumers and preloads. Analysing the two genders separately, differences between preloads were found to be similar in both male and female participants. Differences between consumers differed between genders. Differences between consumers will only be considered in male and female participants separately. The majority of the findings between consumers in all participants can be attributed to the female participants.

9.4.1. EFFECTS OF SWEETNESS (SWEET LUNCH VS. NON-SWEET LUNCH)

In all participants (and in males and females separately), the main differences between preload lunches in this study are:

- Participants reported significantly higher levels of hunger (subjective measures) and consumed more (weight of food) following the sweet lunch than the non-sweet lunch.
- Participants reported significantly higher levels of thirst following the non-sweet compared to the sweet lunch.
- Participants reported a significantly lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch.
- Participants reported a significantly lower appetite for something savoury and appetite for a meal following the non-sweet lunch, compared to the sweet lunch.

Clear differences were found in this study in response to the two differing preload lunches.

Firstly, all participants reported higher levels of hunger and consumed more (weight of food) following the sweet lunch compared to the non-sweet lunch. This is a clear demonstration of an increase in appetite in response to sweetness. This increase in appetite in response to sweetness has previously been widely demonstrated, both in studies investigating responses to sweetness in fluids (see Chapters 2, 6, and 8) and in studies investigating responses to sweetness in solids (Delargy, PhD thesis, 1997; de Graaf, Schreurs and Blauw, 1993). Sweetness independent of energy can increase appetite.

Alternative explanations for a difference between preload lunches in this study however, can also be provided. The two lunches were designed to differ only in taste. Differences were found however in the perceived palatability of the two lunches. High levels of appetite following the sweet lunch may be a result of the increased palatability of the sweet lunch. Increases in palatability have previously been reported to lead to increases in appetite, both subjective (e.g. Hill, Magson and Blundell, 1986) and behavioural (e.g. Perez, Dalix, Guy-Grand and Bellisle, 1994; Rogers and Schutz, 1992). Differences also existed between the two lunches in proportions of carbohydrate and protein, and when included in cumulative intakes across the day, these differences were significant. Protein has frequently been reported to be more satiating than carbohydrate (e.g. Westerterp-Plantenga, Ijedema and Wijckmans-Duijsens, 1996; de Castro, 1987; Hill and Blundell, 1986). Increases in appetite following the sweet lunch may be a result of an increased carbohydrate and decreased protein content of the sweet lunch. Differences also existed between the lunches in carbohydrate source. The sweet lunch contained a much higher proportion of carbohydrate from sugars than the non-sweet lunch. Carbohydrate from sugars has previously been suggested to be less satiating than carbohydrate from starches (Pootihullil, 1992; Rolls, Hetherington and Burley, 1988). An increase in sugar content in the sweet lunch may have resulted in a lower level of satiation following that lunch. No differences in appetite following sugar and starch however, have also been reported (Roger and Blundell, 1989).

Secondly, all participants reported higher levels of thirst following the non-sweet lunch compared to the sweet lunch. This effect has previously been unreported in similar sweet vs. non-sweet meal studies, but may be attributed here to the increased levels of salt in the non-sweet lunch (Carlson, 1986). The persistence of the effect however is surprising. Water was freely supplied in excess during all meals and all participants were free to consume as much water as they wished throughout the day. Large increases in the subjective experiences of thirst following the non-sweet lunch however, may also explain a decreased appetite in response to the non-sweet lunch compared to the sweet lunch (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996).

Thirdly, differences were found between preloads in the subjective measures of specific appetites. All participants reported a lower appetite for something sweet following the sweet lunch than following the non-sweet lunch. Correspondingly, all participants reported a lower appetite for something savoury following the non-sweet lunch than following the sweet lunch. These effects have been reported previously (Delargy, PhD thesis, 1997; de Graaf, Schreurs and Blauw, 1993), and are considered to be clear demonstration of sensory specific satiety (Rolls, Rolls, Rowe and Sweeney, 1981). Effects however are not symmetrical. Appetite for something sweet is much less reduced by the sweet meal than appetite for something savoury is reduced by the non-sweet meal. These findings suggest high overall levels of appetite for sweetness. Appetite for a meal followed a similar pattern to appetite for something savoury. This similarity has also been demonstrated previously (Delargy, PhD thesis, 1997; de Graaf, Schreurs and Blauw, 1993), and can be explained by the fact that meals are typically savoury. Similarities can also be seen in appetite for something savoury, appetite for a meal, and measures of hunger, and can also be explained by the fact that high levels of hunger are typically satisfied by a predominantly savoury meal (de Graaf, 1993).

All effects typically lasted only across the afternoon - i.e. between lunch and tea. Very few effects persisted following tea. This is unsurprising as tea was provided in excess, and both sweet and savoury foods were available.

9.4.2. CONSUMERS - FEMALE PARTICIPANTS

In female participants, the main differences between consumers found in this study are:

- High consumers of sweetened beverages (AC and NC) reported a higher appetite for something sweet than low consumers (WC).
- High consumers of sweetened beverages (AC and NC) reported differing responses to the sweet and the non-sweet lunch (subjective measures of hunger, appetite for something sweet, appetite for something savoury). Low consumers (WC) reported mainly similar responses to the two lunches.
- High consumers of artificially-sweetened beverages (AC) reported higher levels of thirst than low consumers (WC and NC).
- High consumers of artificially-sweetened beverages (AC) reported an increase in appetite for something sweet following the non-sweet lunch compared to baseline measures. Low consumers (WC and NC) reported a decrease in appetite for something sweet following the non-sweet lunch compared to the baseline measures.
- High consumers of artificially-sweetened beverages (AC) reported a similar appetite for something savoury following the sweet lunch compared to baseline measures. Low consumers (WC and NC) reported a decrease in appetite for something savoury following the sweet lunch compared to the baseline measures.

9.4.2.1. High Consumers of Sweetened Beverages (AC and NC) and Low Consumers of Sweetened Beverages (WC)

Several differences were found in this study between female high consumers of sweetened beverages (AC and NC) and low consumers (WC). Firstly, high consumers of sweetened beverages reported a higher appetite for something sweet following both preloads, compared to the low consumers. This higher appetite for something sweet in the sweetened drink consumers is unsurprising. High consumers of sweetened beverages are self-selecting to consume high quantities of sweetened food items. It may be reasoned that these consumers have an increased preference for sweet tasting items (e.g. Laeng, Berridge and Butter, 1993; Conner and Booth, 1988). An increased preference for sweet taste is clearly demonstrated in these consumers in comparing overall appetite for something sweet with overall appetite for something savoury ($t(30)=3.40$, $p=0.004$).

Secondly, female high consumers of sweetened beverages (AC and NC) were found to respond differently to the differing preload lunches, compared to low consumers (WC). Considering first the measures of hunger: low consumers reported similar levels of hunger following both the sweet and the non-sweet lunch. High consumers of sweetened beverages reported higher levels of hunger following the sweet lunch compared to the non-sweet lunch. This difference between consumers can be explained in terms of perceived palatability and familiarity. As mentioned above, high consumers of sweetened beverages are self-selecting to consume high quantities of sweetened food items. It may be reasoned that sweetness is both a highly palatable and highly familiar taste in these consumers. Increases in palatability have previously been demonstrated to increase immediate consumption levels (e.g. Yeomans, Gray, Mitchell and True, 1997; Yeomans, 1996), subsequent subjective measures of appetite (e.g. Hill, Magson, and Blundell, 1986) and subsequent food intake (e.g. Perez, Dalix, Guy-Grand and Bellisle, 1994; Rogers and Schutz, 1992). High levels of familiarity have further been reported to increase perceptions of palatability (Pliner, Pelchat and Grabski, 1993; Pliner 1982). Increases in appetite in response to the sweet lunch compared to the non-sweet lunch in high consumers of sweetened beverages, can be attributed to increases in the perceived palatability of the sweet lunch to these consumers. In low consumers (high consumers of non-sweetened beverages), no increases in hunger were found following either lunch and no differences were found between overall appetites for something sweet and savoury in these consumers ($t(15)=-0.28$, $p=0.78$). Any discrepancies between this explanation and rated pleasantness and tastiness of the two lunches can be attributed to the rating of each lunch only at the end of the meal (Yeomans, 1998). The experience of foods has been reported to markedly alter perceptions of palatability (Yeomans, Gray, Mitchell and True, 1997; Yeomans 1996; Rolls, Rolls, Rowe and Sweeney, 1981).

Considering appetite for something sweet: low consumers of sweetened beverages reported a similar appetite for something sweet following both the sweet and the non-sweet lunch, excepting immediately after the lunch. High consumers reported a lower appetite for something sweet following the sweet lunch than following the non-sweet lunch. A lower appetite for something sweet following the sweet lunch compared to the non-sweet lunch is not demonstrative of an increased preference for sweetness. This difference between consumers suggests differences between consumers in the importance of sweet taste. In the high consumers of sweetened beverages, sweet taste is important, and so is responded to greatly. In the low consumers, sweet taste is of much less importance, so is responded to much less.

Thirdly, differences were also found in appetite for something savoury. Low consumers of sweetened beverages reported a similar appetite for something savoury following both sweet and non-sweet lunches. High consumers of sweetened beverages reported a decreased appetite for something savoury following the non-sweet lunch compared to the sweet lunch. These effects follow a similar pattern to those found in the measures of appetite for something sweet, and suggest high consumers of sweetened beverages to be not only more responsive to sweet taste, but to all tastes. Low consumers appear less responsive to the taste of the lunches and may be more influenced by the energy content of the lunches.

9.4.2.2. High Consumers of Artificially-Sweetened Beverages (AC) and Low Consumers of Artificially-Sweetened Beverages (WC and NC)

Clear differences were also found in this study between female high consumers of artificially-sweetened beverages (AC) and low consumers (WC and NC). These differences can not be explained by differences between the two groups in terms of the perceived palatability of sweetness or familiarity with sweetness, due to the inclusion of the NC consumers as controls for consumption levels of sweetness / sweetened drinks.

Firstly, high consumers of artificially-sweetened beverages reported an increased thirst and desire to drink following both lunches, compared to the low consumers. This effect is surprising. Water was freely supplied in excess during all meals to all participants, and all participants were free to consume as much water as they wished throughout the day. The increases in thirst in the high consumers here may thus be indicative not of increases in thirst, but of an unwillingness to satisfy that thirst with water or non-sweet beverages. Increases in thirst in the high consumers may also be indicative of nothing more than differences between consumers in habitual fluid consumption patterns, or differences in extreme measures of thirst (V.A.S. anchors on which to compare current levels of thirst) (see Hill, Rogers and Blundell, 1995). Differences in thirst however may have implications on effects of hunger (Poppitt, Eckhardt, McGonagle, Murgatroyd and Prentice, 1996), so will be accepted as reported.

Secondly, high consumers of artificially-sweetened beverages reported a significant <u>increase</u> in appetite for something sweet following the non-sweet lunch compared to pre-lunch measures. Low consumers of artificially-sweetened beverages reported a significant <u>decrease</u> in appetite for something sweet in response to the non-sweet lunch, compared to pre-lunch measures. This difference between consumers in appetite for something sweet can be explained in terms of the reliable association between sweetness and energy. If sweetness and energy are reliably associated, similar patterns would be expected between appetite for sweetness and appetite for energy. (Patterns will not be identical due to other independent associations with appetite for sweetness and appetite for energy.) Following a meal, appetite for energy will decrease. By association, appetite for sweetness would similarly be expected to decrease. This is exactly the response seen in the low consumers in this study in appetite for something sweet. If sweetness and energy however, are unassociated, an appetite for sweetness will be unassociated with an appetite for energy.

Following a meal, appetite for sweetness will be unassociated with a decreased appetite for energy. As a highly preferred taste, particularly in those self-selecting high consumption levels of sweetened drinks, and at a time when sweetness has not been experienced for some time, appetite for sweetness might even increase. These effects are exactly those seen in the high consumers of artificially-sweetened beverages in this study. These results thus, may be considered to suggest that the high consumption of sweetness without energy is associated with differing responses to sweetness and energy, or an extinction of the sweetness-energy relationship.

With reference to the differences found above in the subjective measures of thirst, however, the differences between consumers in appetite for something sweet, may be related to the differences between consumers in subjective experiences of thirst. In high consumers of artificially-sweetened beverages, sweetness may be associated with a reduction in thirst. If so, appetite for sweetness would be expected to increase as thirst does. No relationship was found however, in the female high consumers in this study, between ratings of appetite for something sweet and ratings of thirst ($r=0.034$, $p=0.90$) or ratings of desire to drink ($r=0.09$, $p=0.73$) (and see Figure 9.16). The increase in appetite for something sweet following the non-sweet lunch is unlikely to be an effect of an association with thirst.

Thirdly, high consumers of artificially-sweetened beverages reported a similar appetite for something savoury following the sweet lunch compared to pre-lunch measures. Low consumers reported a significant decrease in appetite for something savoury following the non-sweet lunch, compared to pre-lunch measures. This finding can be explained predominantly by the importance of taste. As suggested in the previous section, high consumers of sweetened beverages are responding more to taste than low consumers:- following the sweet lunch, appetite for something sweet was more depressed in the high consumers than in the low consumers, and following the non-sweet lunch appetite for something savoury was more depressed in the high consumers than in the low consumers. The results found in the high consumers of artificially-sweetened beverages in appetite for something savoury following the sweet lunch may be an extension of this increased response to taste. Response patterns are similar in all consumers, only are more marked in the high consumers of artificially-sweetened beverages. Explanation for the increased extremity of the response in the high consumers of artificially-sweetened beverages, however can only be hypothesized. Most plausibly, the extreme response in the high consumers may be indicative of an extreme response to taste or an extreme importance placed on taste in consumption. An extreme response to taste however, may be more easily achieved and may even be indicative of a dissociation not only between sweetness and energy, but between taste and energy. This explanation however is purely speculative. As above, the differing responses following the sweet meal in appetite for something savoury are unlikely to be an effect of an increased thirst. No relationship was found between ratings of appetite for something savoury following the sweet lunch and ratings of thirst ($r=0.17$, $p=0.69$) or ratings of desire to drink ($r=0.24$, $p=0.55$).

(All differences between high and low consumers of artificially-sweetened beverages are also not a result of the very high consumption levels of all sweetened beverages by one of the high consumers of artificially-sweetened beverages. The pattern of findings remain as reported, if this participant is omitted from the analyses.)

9.4.2.3. Summary

In summary, in female participants, differences were found between high and low consumers of sweetened beverages and high and low consumers of artificially-sweetened beverages. Compared to the low consumers, high consumers of sweetened beverages reported an increased preference for sweet taste and increases in appetite following a sweet lunch. All differences can be explained by the increased preference for and increased importance of sweet taste, and possibly all tastes in the high consumers. Compared to the low consumers of artificially-sweetened beverages, high consumers reported higher levels of thirst, increases in appetite for something sweet following the non-sweet lunch and a similar level of appetite for something savoury following the sweet lunch, compared to pre-lunch measures. Following both lunches, low consumers reported decreases in appetite for something sweet and appetite for something savoury. High levels of thirst can be explained as a result of habitual high consumption levels of fluids. Differences in appetite for something sweet are considered to be indicative of a dissociation between sweetness and energy, in the high consumers. Differences in appetite for something savoury may be considered indicative of an increased response to taste and an increased importance of taste in appetite in the high consumers of artificially-sweetened beverages. This study thus suggests that in females, the habitual high consumption of sweetness without energy is associated with an increased response to and importance of sweet taste and taste in appetite, and a demonstration of an extinction of the sweetness-energy relationship.

9.4.3. CONSUMERS - MALE PARTICIPANTS

9.4.3.1. High Consumers of Sweetened Beverages (AC and NC) and Low Consumers of Sweetened Beverages (WC)

In male participants in this study, only one difference was found between male high and low consumers of sweetened beverages. High consumers (AC and NC) consumed a similar weight of food following both lunches. Low consumers (WC) consumed more weight of food following the non-sweet lunch than following the sweet lunch. This finding is perplexing: no differences were found in the low consumers in overall appetites for something sweet or something savoury ($t(7)=-1.16$, $p=0.29$). It should be noted however, that whilst consistent throughout measures of weight of food consumed, this increase in appetite was not found in measures of energy or in subjective measures of appetite.

9.4.3.2. High Consumers of Artificially-Sweetened Beverages (AC) and Low Consumers of Sweetened Beverages (WC and NC)

In male participants in this study, no differences were found between high consumers of artificially-sweetened beverages (AC) and low consumers (WC and NC). The absence of differences in male consumers suggests the habitual consumption of sweetness without energy to have no effects on appetite in males.

The absence of effects in males and the differences between males and females can be explained (as in previous studies), by a reduced importance of taste in appetite in males. Recent research has suggested taste to be more influential in appetite in females than in males (Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998; Yeomans, 1996; Zylan, 1996; Beatty, 1982; Rolls, Fedoroff and Guthrie, 1991). Male participants in this study were also found to show no preferences for differing tastes and were responding to the differing preload lunches much less than females. The absences of effects in male participants, the presence of effects in female participants and the differences between males and females participants, may thus all be a result of the underlying importance placed on taste in appetite.

9.4.3.3. Summary

In summary, in male participants, very few differences were found between high and low consumers of sweetened beverages and no differences were found between high and low consumers of artificially-sweetened beverages. The absence of effects can be explained by a reduced importance of taste in appetite in males.

9.4.4. ADDITIONAL FINDINGS

Three additional findings in this study are worthy of comment. Firstly, direct differences were found between genders in all measures of appetite. Males reported higher levels of hunger and consumed more (weight of food) than females. These effects are unsurprising, and have been reported previously (e.g. Rolls, Fedoroff and Guthrie, 1991).

Secondly, the majority of effects found in this study were found in the subjective measures of appetite and not in the behavioural measures. The absence of effects in the behavioural measures can be attributed to the experimental procedure. All participants were constrained from consumption for four hours following lunch and were then provided with a large ad-libitum test meal. The time delay of four hours and the provision of a large test meal, both may have reduced the sensitivity of that meal (Hill, Rogers and Blundell, 1995). Support for these possibilities are also found in the temporal patterns of the subjective measures of appetite throughout the afternoon. Immediately following lunch, differences in subjective measures of appetite are wide in range. Four hours later and immediately before the provision of a large test meal, differences in appetite are very constricted.

Thirdly, differences were found in the behavioural measures of appetite in the proportions of energy consumed from each macronutrient. In analysing all participants, males were found to consume less energy from carbohydrate and more energy from fat than females. Also in female participants, high consumers of artificially-sweetened beverages were found to consume less energy from carbohydrate than low consumers. These effects are unlikely to be anything more than indicative of food preferences within the limited choice of foods available in the test meal/period.

9.5. SUMMARY

In summary: in female participants, compared to the low consumers of artificially-sweetened beverages, high consumers reported higher levels of thirst, increases in appetite for something sweet following the non-sweet lunch and a similar level of appetite for something savoury following the sweet lunch, compared to pre-lunch measures. Following both lunches, low consumers reported decreases in appetite for something sweet and appetite for something savoury. High levels of thirst can be explained as a result of habitual high consumption levels of fluids. Differences in appetite for something sweet are considered to be a demonstration of differing responses to sweetness and energy, and a possible extinction of the sweetness-energy relationship, in the high consumers. Differences in appetite for something savoury are considered indicative of an increased response to taste and an increased importance of taste in appetite in the high consumers of artificially-sweetened beverages. High consumers of sweetened beverages were also found to report higher levels of appetite for sweetness and higher levels of appetite following sweetness. These effects are explained by increased preferences for and an increased perceived palatability of sweet taste in these consumers and suggest an increased importance of taste in appetite. No effects were found in this study in the male participants. This, and the differences between male and female participants are explained in terms of taste preferences and the importance of taste in appetite.

Chapter 10.

STUDY 6:

UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE:

RESPONSES TO SWEETNESS, SWEETNESS INTENSITY AND DIETARY FAT CONTENT

ABSTRACT

This study investigates the responses to sweetness, sweetness intensity and dietary fat content in male and female, high and low consumers of artificially-sweetened beverages. Subjective appetite was measured following 20 stimuli varying in sweetness intensity (0% - 20%) and dietary fat content (0.1% - 48.0%). In all measures of subjective appetite, in male and female participants, few differences were found between consumers and no interactions were found between consumers and differing sweetness intensities or differing levels of dietary fat content. All differing sweetness intensities and dietary fat content levels however, were detected and differentiated, irrespective of consumer type. These findings suggest either that differences between consumers do not exist, or that differences between high and low consumers of artificially-sweetened beverages were not detected in this study. The validity of the methodology used in this study is severely questioned. Slight differences were found between consumers in ratings of sweetness. Whilst the methodology of the study is severely questioned, these findings may provide limited evidence that the high consumption of artificially-sweetened beverages is <u>not</u> associated with an habituation to sweetness.

10.1. INTRODUCTION

As discussed in Chapter 3, uncoupling sweetness and energy in habitual high consumers of artificial sweeteners may also result in a number of effects on specific appetites - those for sweetness and those for dietary fat. As a result of the habitual uncoupling of sweetness and energy, the habitual high consumption of sweetness without energy is suggested to result in a continued high consumption of and preference for sweetness. As a result of the habitual high consumption of sweetness, the habitual high consumption of sweetness without energy is suggested to result in high preferences for and consumption of sweetness. As a result of the habitual high consumption of sweetness, the habitual high consumption of sweetness without energy is also suggested to result in a possible habituation to sweetness, and increases in the preferred amounts and intensities of sweetness. As a result of the habitual high consumption of artificial sweeteners, the habitual high consumption of sweetness without energy is suggested to result in possible increases in dietary fat consumption and preferences for dietary fat.

A continued consumption of sweetness can not be investigated in habitual high consumers of artificially-sweetened beverages at one time point. Preferences for sweetness,

sweetness intensities and dietary fat content however, can be easily investigated at one time point by the comparison of habitual high and low consumers of artificially-sweetened beverages. Preferences for sweetness, sweetness intensities and dietary fat content, can be investigated in the laboratory using a taste-testing procedure. The value of the taste-testing procedure in investigating sweetness and fat preferences has previously been widely demonstrated (e.g. Monneuse, Bellisle and Louis-Sylvestre, 1991a; Drewnowski, Halmi, Pierce, Gibbs and Smith, 1987; Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1985: Drewnowski and Greenwood, 1983). Responses to sweetness, sweetness intensity and dietary fat content, in association with the habitual consumption of sweetness without energy, will be investigated in this study using a taste-testing procedure.

Preferences for sweetness and dietary fat can also be investigated naturalistically, by analysis of the typical diet. A naturalistic investigation of preferences for sweetness and fat, in association with the habitual consumption of sweetness without energy, is included in Study 8.

10.1.1. AIMS

This study aims to investigate the responses to sweetness, sweetness intensity and dietary fat content in habitual high and low consumers of sweetness without energy. Responses to sweetness, sweetness intensity and dietary fat content will be investigated using a taste-testing procedure. Habitual high and low consumers of sweetness without energy will be defined as detailed in Chapter 7. Low consumers will additionally be defined either as high consumers of naturally-sweetened beverages or as high consumers of non-sweet/low energy beverages (see Chapter 9).

10.2. METHOD

10.2.1. DESIGN

The study uses a 2 x 3 x 5 x 4 mixed design, investigating gender (2 levels), consumer type (3 levels), sweetness intensity (5 levels), and dietary fat content (4 levels). The study was conducted using a taste-testing procedure, where sweetness, sweetness intensity and dietary fat content were experienced as taste-test stimuli and responses were subsequently measured using subjective measures.

10.2.2. CONSUMERS

Three independent groups of consumers participated in the study - habitual high consumers of artificially-sweetened beverages (AC), habitual low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC), and habitual low consumers of artificially-sweetened beverages but high consumers of non-sweet/low energy beverages (WC). Habitual high consumers of artificially-sweetened beverages (AC) were required to be consuming ≥ 825 ml (artificially-sweetened beverages)/day. Habitual high consumers of naturally-sweetened beverages (NC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (naturally-sweetened beverages)/day. Habitual high consumers of non-sweet/low energy beverages (WC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (non-sweet/low energy beverages)/day. Consumption levels of all beverages were reported by all participants on a self-report Drinks F.F.Q., completed prior to inclusion in the study (see Appendix 8.1). Naturally-sweetened beverages were considered to be tea or coffee sweetened with natural sweeteners (sugar, honey), fruit juices, regular carbonated drinks, regular squash, hot chocolate, and milkshakes. Non-sweet/low energy beverages were considered to be unsweetened tea or coffee or water. Equal numbers of males and females participated in the study.

In total, 16 habitual high artificially-sweetened beverage consumers (AC)(8 male and 8 female), 16 habitual high naturally-sweetened beverage consumers (NC)(8 male and 8 female) and 16 habitual high non-sweet beverage consumers (WC)(8 male and 8 female) took part in the study. Prior to the start of the study, all participants were measured for calculation of B.M.I. and completed the D.E.B.Q., as a measure of dietary restraint. Consumer groups were matched as closely as possible on B.M.I. and dietary restraint (D.E.B.Q.-R.) scores. All participants were familiar with and liked all stimuli components used in the study. None of the participants were informed of the exact hypotheses of the study. Participant characteristics are displayed in Table 10.1.

Table 10.1: Participant Characteristics (mean (standard deviation))

Participants	Beverage Consumption (ml/day)				
	Artificially-sweetened	Total Sweetened	Total	B.M.I. (kg/m^2)	D.E.B.Q.-R. score
WC - M (N=8)	0.0 (0.0)	409.1 (196.6)	1960.4 (459.5)	22.9 (2.9)	13.4 (4.6)
WC - F (N=8)	0.0 (0.0)	274.3 (226.3)	1639.9 (431.1)	21.9 (2.3)	30.3 (8.5)
AC - M (N=8)	1051.3 (202.9)	1337.5 (273.3)	2032.6 (584.1)	25.3 (2.4)	28.9 (6.2)
AC - F (N=8)	1914.7 (1047.7)	2087.0 (965.3)	2805.3 (988.5)	23.6 (3.3)	30.5 (10.7)
NC - M (N=8)	0.0 (0.0)	1470.5 (420.1)	1845.5 (775.9)	24.9 (6.2)	16.6 (5.2)
NC - F (N=8)	0.0 (0.0)	1238.4 (305.2)	1489.3 (240.9)	22.9 (5.6)	24.0 (3.7)

WC = High Consumers of Non-Sweet/Low Energy Beverages, AC = High Consumers of Artificially-Sweetened Beverages; NC = Consumers of Naturally-Sweetened Beverages; M = Males; F = Females

10.2.3. SWEETNESS INTENSITY AND DIETARY FAT CONTENT

Five differing levels of sweetness intensity were tested in the study - 0%, 5%, 10%, 15%, and 20% weight by weight (gram./gram.). Four differing levels of dietary fat content were tested in the study - 0.1%, 4.0%, 18.0%, and 48.0% weight by weight (gram./gram.). All combinations of sweetness intensity and dietary fat level were used as stimuli, forming 20 stimuli in total. All stimuli were composed of a combination of milk and sugar. Differing intensities of sweetness were achieved by adding differing amounts of sugar to the stimuli. Differing levels of dietary fat were achieved by utilising skimmed milk (0.1%), whole milk (4.0%), single cream (18.0%), or double cream (48.0%), as the base for each stimulus.

All participants received all 20 stimuli. The order of presentation of the stimuli was fully multi-condition counterbalanced across all participants.

10.2.4. MEASURES OF SUBSEQUENT APPETITE

Responses to sweetness intensity and dietary fat content were measured immediately after experiencing each stimulus using subjective measures of appetite. Subjective perceptions were measured using 100mm V.A.S. of Pleasantness, Sweetness, Fattiness, Potential Ability to Fill, and Potential Ability to Satisfy. Behavioural measures were not taken.

10.2.5. PROCEDURE

All stimuli were tasted in a single test session, lasting approximately 15 min. For each stimulus, all participants received 20ml of stimulus and were asked to experience as much of the stimulus as they wished for approximately 2 sec. The fixed timing of stimulus experience minimized differences in experience of each stimulus between stimuli and participants. The quantity experienced was not controlled to ensure sufficient experience of each stimulus to enable taste rating. Small differences in quantity experienced were considered to be unlikely to affect stimulus ratings (see Monneuse, Bellisle and Louis-Sylvestre, 1991a, Monneuse, Bellisle and Louis-Sylvestre, 1991b). Following tasting, all stimuli were expectorated. Expectoration was employed to minimize differences in stomach fullness and hunger as the test proceeded. Stomach fullness and hunger have previously been found to influence perceptions of taste (Monneuse, Bellisle and Louis-Sylvestre, 1991a). All stimuli were alternated with a sip of water (also expectorated), to cleanse the palate between stimuli.

All tasting sessions were conducted either mid-morning or mid-afternoon, to minimize differences in initial levels of hunger between all participants. All participants were also instructed not to consume anything at least 2 hours prior to the taste test, to ensure that no prior taste in the mouth could influence perceptions of the test stimuli (Monneuse, Bellisle and Louis-Sylvestre, 1991a).

10.2.6. ANALYSIS

Participant Characteristics: Prior to analysis of the dependent measures in this study, all consumer groups were compared in terms of artificially-sweetened beverage consumption, total sweetened beverage consumption, B.M.I. and Dietary Restraint Score. Groups of high and low consumers were designed to differ in terms of artificially-sweetened beverage consumption. Groups of AC and NC consumers were designed to be similar in terms of total sweetened beverage consumption. All groups were designed to be similar in terms of B.M.I. and Restraint. If differences were found between consumer groups, or if a significant relationship was found between B.M.I. and/or Dietary Restraint and the sum of ratings of pleasantness for all stimuli, B.M.I. and/or Dietary Restraint Score were included in all analyses as covariates. B.M.I. has previously been shown to influence stimulus ratings in this type of taste test (e.g. Rodin, Moskowitz and Gray, 1976). Influence of dietary restraint can be inferred from tests conducted on participants differing in dieting patterns (Drewnowski, Kurth and Rahaim, 1991) and eating disorder classification (Drewnowski, Halmi, Pierce, Gibbs and Smith, 1987). Participant characteristics were analysed by 1-way ANOVA (6 groups) and Pearson Product Moment Correlations.

Subjective Measures of Appetite: All subjective perceptions of appetite are described as profiles across all stimuli, and were analysed using 4-way repeated measures ANCOVA (gender by consumer by sweetness intensity by dietary fat level, covariate - Dietary Restraint Score). Data for the male participants were also analysed using 3-way repeated measures ANCOVA (consumer by sweetness intensity by dietary fat level, covariate - Dietary Restraint Score). Data for the female participants were analysed using 3-way repeated measures ANOVA (consumer by sweetness intensity by dietary fat level).

All participants provided a complete data set.

10.3. RESULTS

Note: WC consumers = low consumers of artificially-sweetened beverages, high consumers of non-sweetened beverages; AC = high consumers of artificially-sweetened beverages; NC consumers = low consumers of artificially-sweetened beverages, high consumers of naturally-sweetened beverages.

10.3.1. PARTICIPANT CHARACTERISTICS

10.3.1.1. Artificially-Sweetened Beverage Consumption

High (AC) and low (WC, NC) consumers were designed to differ in artificially-sweetened beverage consumption. Significant differences were found ($F(5,47)=27.86$, $p<0.001$). Male AC consumers consumed more artificially-sweetened beverages than male and female WC and NC consumers (all $t(14)=-14.65$, $p<0.001$). Female AC consumers consumed more artificially-sweetened beverages than male and female WC and NC consumers (all $t(14)=-5.17$, $p<0.001$). Significant differences were also found between male and female AC consumers ($t(14)=-2.29$, $p=0.04$). Female AC consumers also reported consuming more artificially-sweetened beverages than male AC consumers. This difference will be borne in mind when comparing findings between genders. No differences were found between male and female WC and NC consumers.

10.3.1.2. Total Sweetened Beverage Consumption

High consumers of artificially-sweetened beverages (AC) and high consumers of naturally-sweetened beverages (NC) were also designed not to differ in total sweetened beverage consumption. Significant differences however were found ($F(5,47)=3.64$, $p=0.02$). Female AC consumers reported consuming more sweetened beverages than female NC consumers ($t(14)=2.37$, $p=0.03$). This difference will be borne in mind when comparing findings between all female consumers. No other differences were found (largest $t(14)=-2.11$, $p=0.053$ (adjusted significance)).

10.3.1.3. B.M.I.

Groups of consumers were designed to be similar in B.M.I. No significant differences were found between consumer groups in B.M.I. ($F(5,47)=0.81$, $p=0.55$). No relationship was found between B.M.I. and the sum of ratings of pleasantness for all stimuli (all participants: $r=0.067$, $p=0.31$; male participants: $r=0.170$, $p=0.07$; female participants: $r=0.147$, $p=0.11$). B.M.I. was not used as a covariate in any analyses.

10.3.1.4. Dietary Restraint

Groups of consumers were designed to be similar in Dietary Restraint. Significant differences were found between consumer groups in D.E.B.Q.-R. scores ($F(5,47)=9.01$, $p<0.001$). Male WC consumers were significantly less restrained than male AC consumers, female AC consumers, female WC consumers and female NC consumers (smallest $t(14)=-4.13$, $p=0.001$). Male NC consumers were significantly less restrained than male AC consumers, female AC consumers, female WC consumers and female NC consumers (smallest $t(14)=-3.26$, $p=0.01$). No significant differences were found between male WC and NC consumers ($t(14)=-1.32$, $p=0.21$). No significant differences were found between the four more highly restrained groups (male AC, female WC, AC, NC) (largest $t(14)=1.90$, $p=0.08$). No relationship was found between Restraint and the sum of ratings of pleasantness for all stimuli (all participants: $r=0.062$, $p=0.34$; male participants: $r=-0.025$, $p=0.79$; female participants: $r=0.089$, $p=0.34$).

Due to the differences found between groups and the potential influence on the stimulus ratings of dietary restraint, D.E.B.Q.-R. score was used as a covariate in all analyses concerning all participants, and in all analyses only on male participants. The significance of the covariate are shown following all analyses in Appendix 10.8.

10.3.2. SUBJECTIVE MEASURES OF APPETITE

Note: All stimuli are as labelled in Table 10.2.

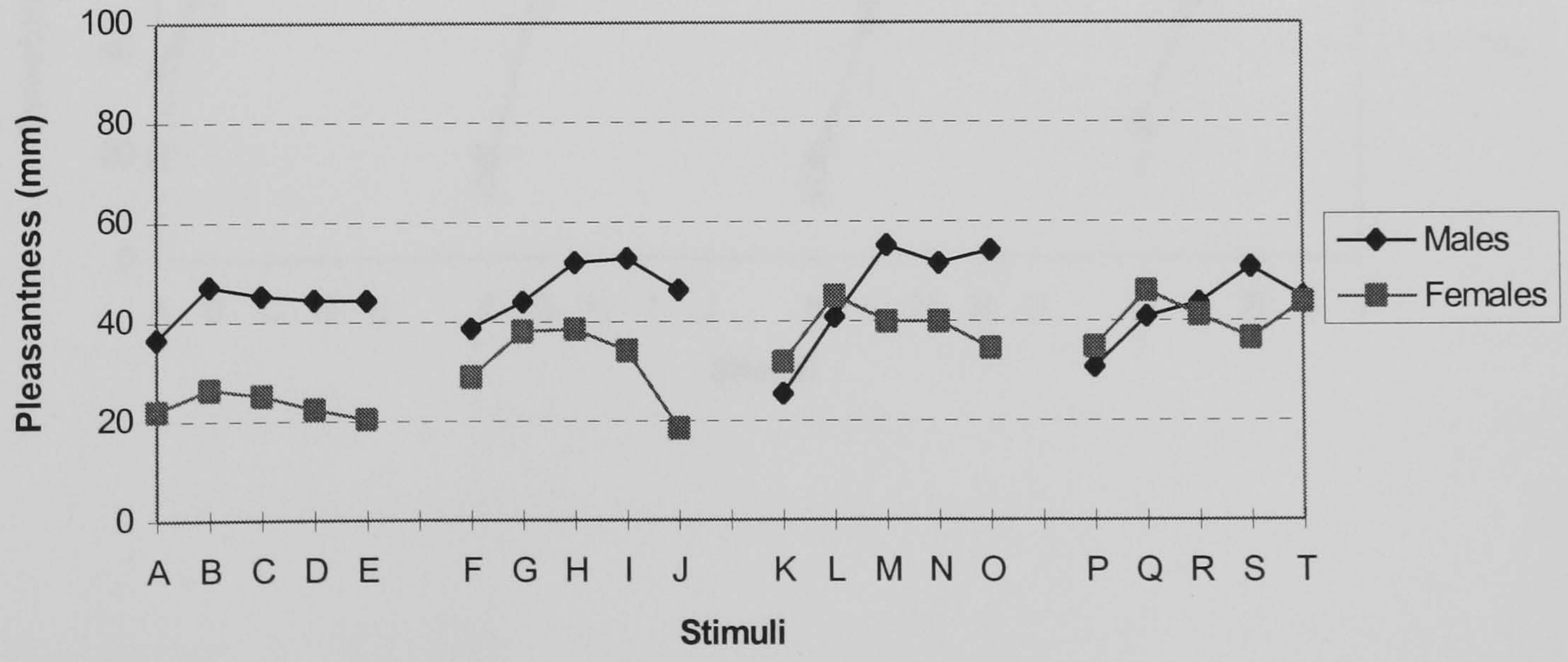
Table 10.2: Alphabetic Labels for All Stimuli

		Sweetness Intensity				
		0%	5%	10%	15%	20%
Dietary Fat Content	0.1%	A	B	C	D	E
	4.0%	F	G	H	I	J
	18.0%	K	L	M	N	O
	48.0%	P	Q	R	S	T

10.3.2.1. All Participants

Significant differences were found between genders in scales of pleasantness ($F(1,41)=17.87$, $p<0.001$), fattiness ($F(1,41)=11.64$, $p=0.001$), potential ability to fill ($F(1,41)=5.08$, $p=0.03$) and potential ability to satisfy ($F(1,41)=6.30$, $p=0.02$). Male participants rated all stimuli more pleasant, more fatty, potentially more able to fill and potentially more able to satisfy than female participants. The profile of Pleasantness for all stimuli (gender by stimuli) is shown in Figure 10.1. Profiles of Sweetness, Fattiness, Potential Ability to Fill and Potential Ability to Satisfy for all stimuli for all participants (gender by stimuli) are shown in Appendices 10.1 - 10.4.

Figure 10.1: Profile of Ratings of Pleasantness for all Stimuli for All Participants - Gender by Stimuli



Significant differences were found between consumers in the scale of sweetness (F(2,41)=3.66, p=0.03). AC consumers rated all samples more sweet than NC consumers (t(30)=2.48, p=0.02). No differences were found between AC and WC consumers (t(30)=-0.90, p=0.38) or WC and NC consumers (t(30)=-1.65, p=0.11). Profiles of Pleasantness, Sweetness and Fattiness for all stimuli (consumer by stimuli) are shown below in Figures 10.2 - 10.4. Profiles of Potential Ability to Fill and Potential Ability to Satisfy for all stimuli (consumer by stimuli) are shown in Appendices 10.5.- 10.6.

Figure 10.2: Profile of Ratings of Pleasantness for all Stimuli for All Participants - Consumer by Stimuli

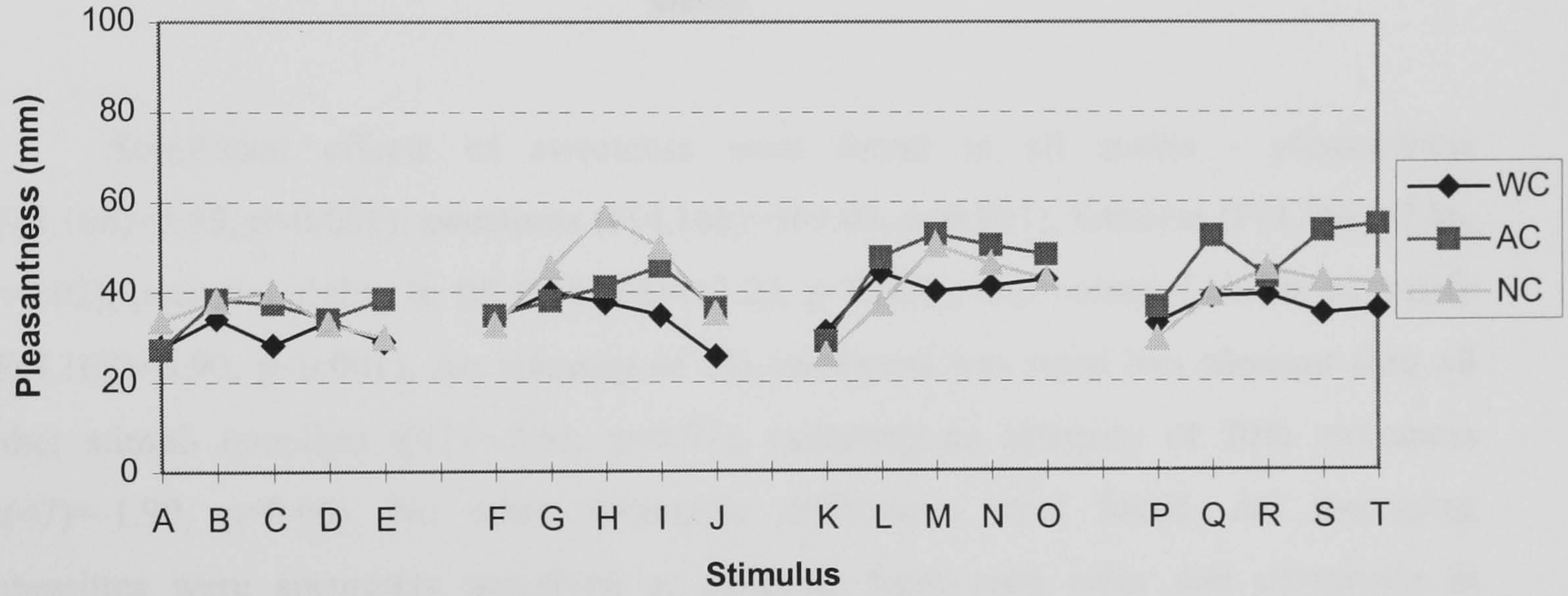


Figure 10.3: Profile of Ratings of Sweetness for all Stimuli for All Participants - Consumer by Stimuli

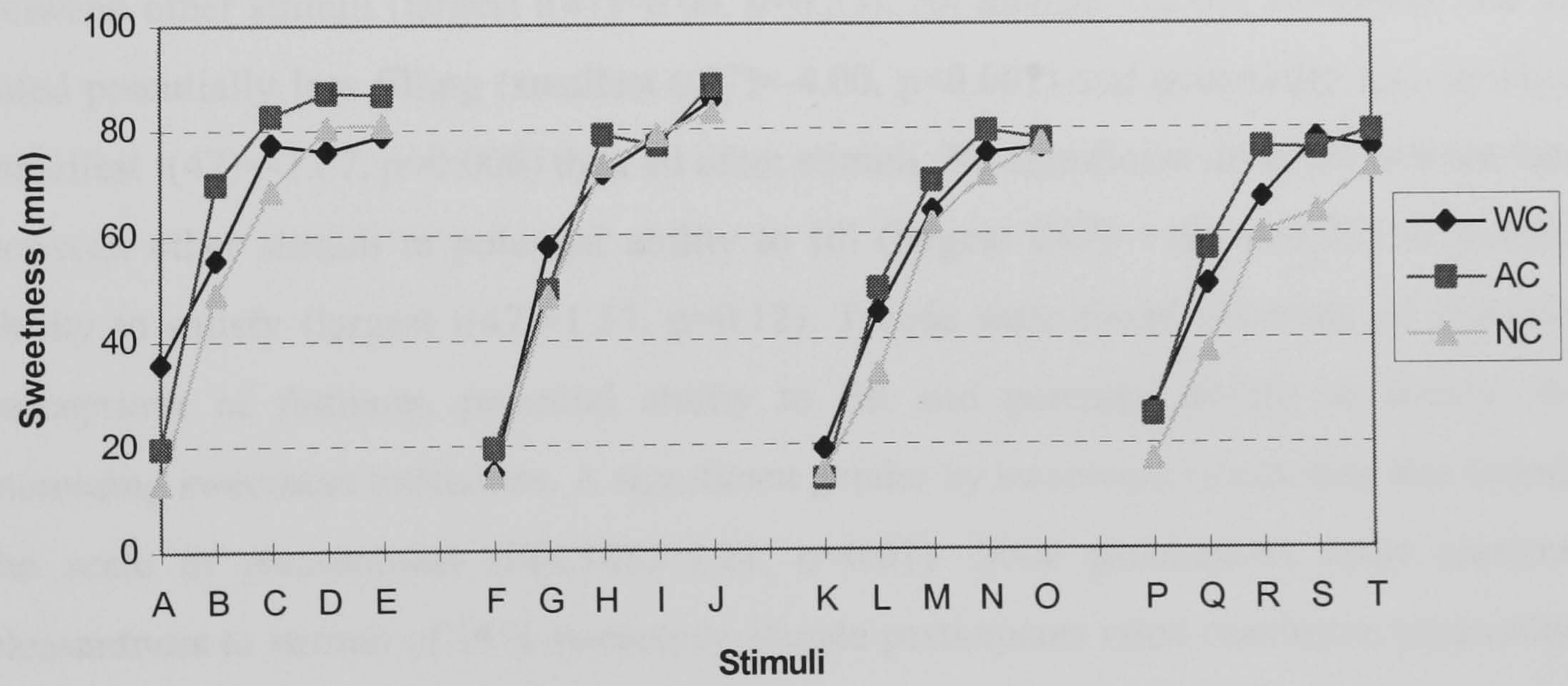
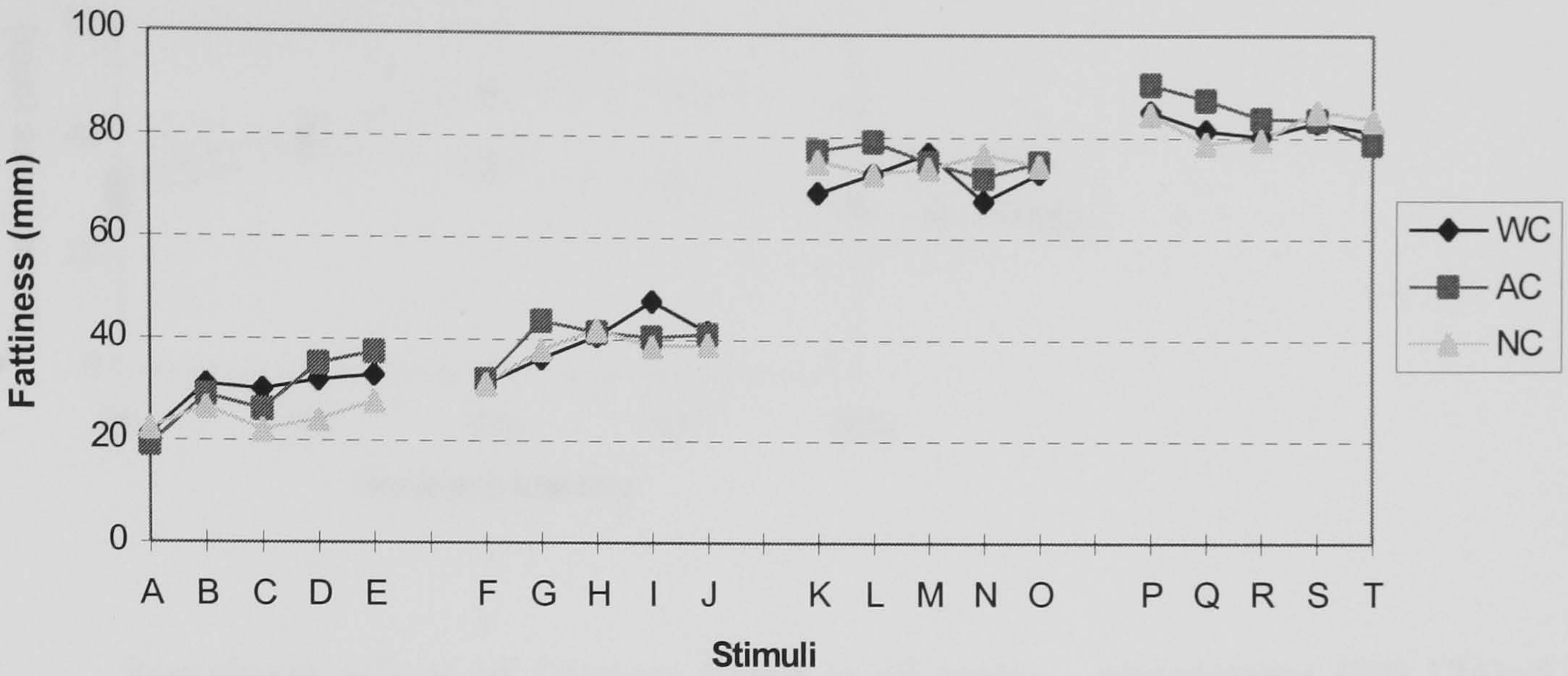
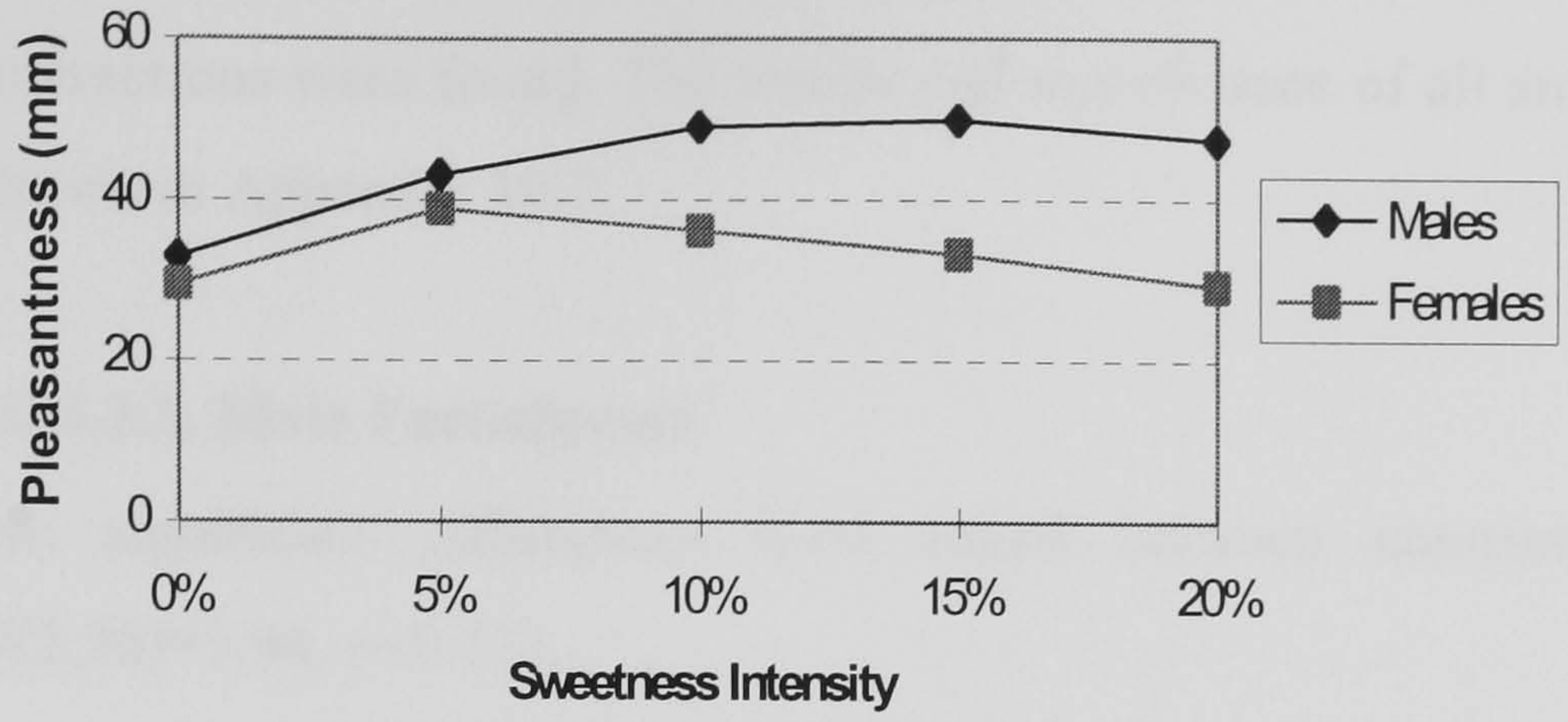


Figure 10.4: Profile of Fattiness for all Stimuli for All Participants - Consumer by Stimuli



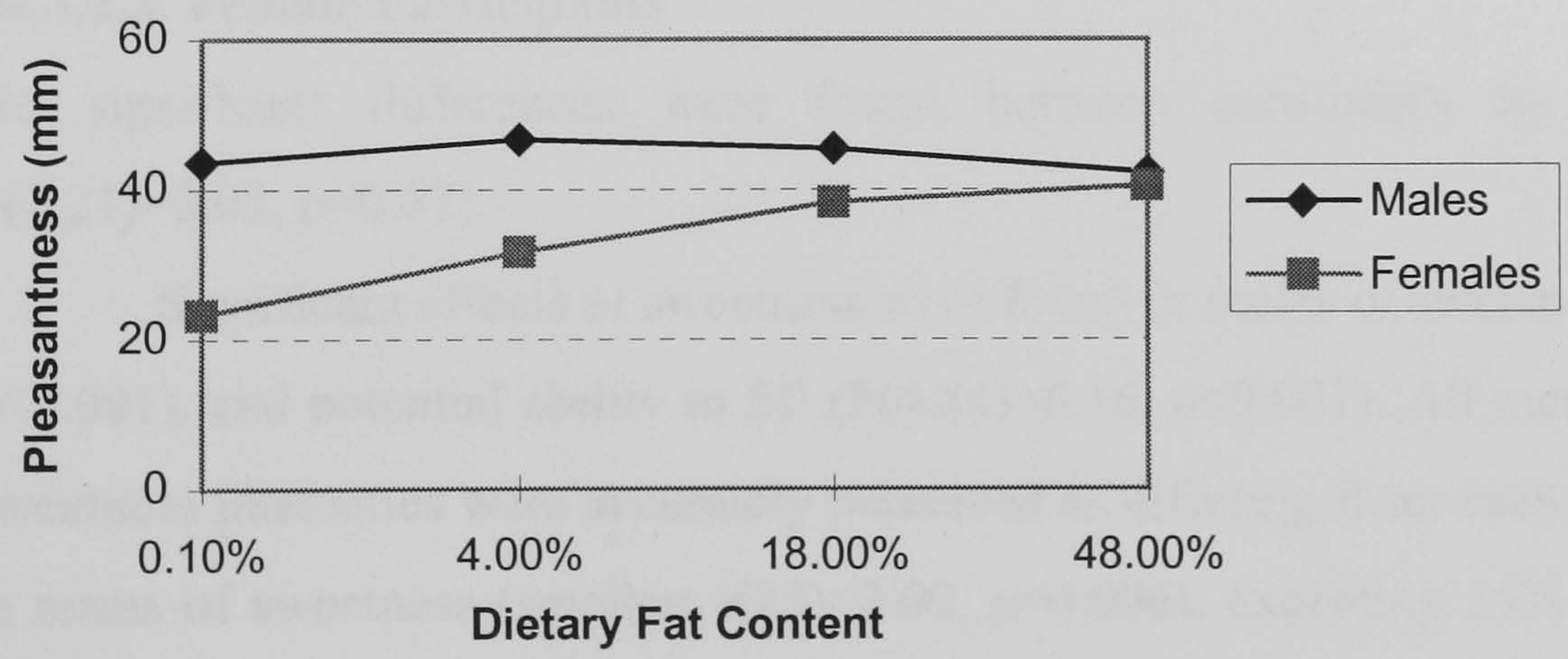
Significant effects of sweetness were found in all scales - pleasantness (F(4,168)=5.89, p<0.001), sweetness (F(4,168)=369.03, p<0.001), fattiness (F(4,168)=2.86, p=0.02), potential ability to fill (F(4,168)=13.22, p<0.001), and potential ability to satisfy (F(4,168)=6.90, p<0.001). An intensity of 0% sweetness was rated less pleasant than all other stimuli (smallest t(47)=-2.62, p=0.01), excepting an intensity of 20% sweetness (t(47)=-1.90, p=0.06). No other systematic differences were found. All increasing intensities were accurately perceived as differing from each other and increasing in sweetness (smallest t(47)=-2.61, p=0.01). An intensity of 0% sweetness was rated less fatty than all other stimuli (smallest t(47)=-2.01, p=0.05). No significant differences were found between other stimuli (largest t(47)=0.60, p=0.55). An intensity of 0% sweetness was also rated potentially less filling (smallest t(47)=-4.00, p<0.001) and potentially less satisfying (smallest t(47)=-2.87, p=0.006) than all other stimuli. No significant differences were found between other stimuli in potential ability to fill (largest t(47)=1.60, p=0.12) or potential ability to satisfy (largest t(47)=1.57, p=0.12). Trends were found however, of increasing perceptions of fattiness, potential ability to fill and potential ability to satisfy, with increasing sweetness intensities. A significant gender by sweetness interaction was found in the scale of pleasantness (F(4,168)=3.21, p=0.01). Male participants rated maximum pleasantness to stimuli of 15% sweetness, female participants rated maximum pleasantness to stimuli of 5% sweetness. The profile of Pleasantness for all sweetness intensities for all participants (gender by sweetness intensity) is shown in Figure 10.5.

Figure 10.5: Profile of Pleasantness for all Sweetness Intensities for All Participants - Gender by Sweetness Intensity



Significant effects of fat were found in all scales - pleasantness (F(3,126)=5.57, p=0.001), sweetness (F(3,126)=9.10, p<0.001), fattiness (F(3,126)=398.48, p<0.001), potential ability to fill (F(3,126)=185.14, p<0.001) and potential ability to satisfy (F(3,126)=19.04, p<0.001). Levels of 0.1% fat content were rated less pleasant than all other stimuli (smallest t(47)=-2.57, p=0.01). No differences were found between other levels of fat content (largest t(47)=1.27, p=0.21) (trend toward increasing ratings of pleasantness with increasing dietary fat content). A significant gender by sweetness interaction was found in the scale of pleasantness (F(3,126)=6.31, p=0.001). Females reported increasing levels of fat content as increasingly pleasant; males rated all levels of fat content equally pleasant. The profile of Pleasantness for all levels of dietary fat content for all participants (gender by dietary fat content) is shown in Figure 10.6.

Figure 10.6: Profile of Pleasantness for all Levels of Dietary Fat Content for All Participants - Gender by Dietary Fat Content



Levels of 0.1% and 4.0% fat content were also rated more sweet than levels of 18.0% and 48.0% fat content (smallest t(47)=2.72, p=0.01). No differences were found between lower levels of fat content or higher levels of fat content (largest t(47)=-1.85, p=0.07). All increasing levels of fat content were accurately perceived as differing from each other and increasing in fattiness (smallest $t(47)=6.29$, $p<0.001$), in potential ability to fill ($t(47)=5.06$, $p<0.001$) and in potential ability to satisfy (smallest $t(47)=3.03$, $p<0.001$). No systematic interactions were found. The results and significance of all analyses on all participants are shown in Appendix 10.7.

10.3.2.2. Male Participants

No significant differences were found between consumers in any scale (largest $F(2,20)=1.94$, $p=0.17$).

Significant effects of sweetness were found in scales of pleasantness ($F(4,84)=8.21$, $p<0.001$), sweetness ($F(4,84)=212.87$, $p<0.001$), potential ability to fill ($F(4,84)=7.61$, $p<0.001$), and potential ability to satisfy ($F(4,84)=9.24$, $p<0.001$). Intensities of 0% and 5% sweetness were rated less pleasant, potentially less able to fill and potentially less able to satisfy than higher intensities of sweetness. All increasing intensities of sweetness were accurately perceived as differing from each other and increasing in terms of sweetness (smallest $t(23)=-2.85$, $p=0.01$). No systematic interactions were found.

Significant effects of fat content were found in scales of sweetness ($F(3,63)=14.10$, $p<0.001$), fattiness ($F(3,63)=265.98$, $p<0.001$), and potential ability to fill ($F(3,63)=91.12$, $p<0.001$). Levels of 0.1% and 4.0% fat content were rated as more sweet than levels of 18.0% and 48.0% fat content. All increasing levels of fat content were accurately perceived as differing from each other and increasing in terms of fattiness (smallest $t(23)=-4.16$, $p<0.001$), and in terms of potential ability to fill (smallest $t(23)=-2.23$, $p=0.04$). No systematic interactions were found.

10.3.2.3. Female Participants

No significant differences were found between consumers in any scale (largest $F(2,21)=3.02$, $p=0.07$).

Significant effects of sweetness were found in scales of sweetness ($F(4,84)=166.01$, $p<0.001$), and potential ability to fill ($F(4,84)=6.16$, $p<0.001$). All increasing intensities of sweetness intensities were accurately perceived as differing from each other and increasing in terms of sweetness (smallest $t(23)=3.00$, $p=0.006$), excepting 15% and 20% sweetness ($t(23)=-1.11$, $p=0.28$). Intensities of 0% sweetness were rated potentially less able to fill than all other intensities of sweetness (smallest $t(23)=-2.75$, $p=0.01$) No differences were found between other intensities (largest $t(23)=-1.02$, $p=0.32$). No interactions were found.

Significant effects of fat content were found in scales of pleasantness ($F(3,63)=9.99$, $p<0.001$), fattiness ($F(3,63)=169.23$, $p<0.001$), potential ability to fill ($F(3,63)=95.97$, $p<0.001$), and potential ability to satisfy ($F(3,63)=25.53$, $p<0.001$). Levels of 0.1% and 4.0% fat content were rated as less pleasant than levels of 18.0% and 48.0% fat content. All increasing levels of fat content were accurately perceived as differing from each other and increasing in terms of fattiness (smallest $t(23)=-4.66$, $p<0.001$), in potential ability to fill (smallest $t(23)=-5.12$, $p<0.001$), and in potential ability to satisfy (smallest $t(23)=-2.06$, $p=0.05$). No systematic interactions were found.

10.4. DISCUSSION

In analysing all participants, differences were found in this study between genders, sweetness intensity and dietary fat content. No differences were found between consumers. In analysing male and female participants separately, differences were found between sweetness intensity and dietary fat content. No differences were found between consumers. The differences in sweetness intensity and dietary fat content were similar in all participants, in male participants and in female participants.

10.4.1. SWEETNESS INTENSITY AND DIETARY FAT CONTENT

In all participants (and in male and female participants separately), the main findings in sweetness intensity and dietary fat content in this study are:

- Increasing intensities of sweetness were accurately rated as increasingly sweet.
- Increasing levels of dietary fat content were accurately rated as increasingly fatty.
- Increasing intensities of sweetness were rated as increasingly more pleasant toward a specific intensity, then increasingly less pleasant.
- Increasing intensities of sweetness were rated as more fatty, potentially more filling and potentially more satisfying.
- Increasing levels of dietary fat content were rated as more pleasant.
- Increasing levels of dietary fat content were rated as less sweet, increasingly potentially more filling and increasingly potentially more satisfying.

Clear effects of sweetness intensity and dietary fat content were found in this study. Firstly, all increasing intensities of sweetness and increasing levels of dietary fat content were accurately rated by all participants, as differing from each other and as increasing in sweetness intensity and/or dietary fat level. These findings suggest the nutritional manipulation to have been accurately detected and experienced by all participants.

Clear effects of sweetness intensity and dietary fat content were also found in the more interpretative subjective measures. Increasing intensities of sweetness were rated as increasingly more pleasant toward a specific sweetness intensity, then as increasingly less pleasant. This inverted U-shaped function in preference responses to sweetness has frequently been previously reported (e.g. Drewnowski, Halmi, Pierce, Gibbs and Smith, 1987; Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1985; Drewnowski and Greenwood, 1983). Increasing intensities of sweetness were also rated as more fatty, potentially more able to fill and potentially more able to satisfy. These effects are most plausibly explained as a result of previous experience. The effects in potential ability to fill and potential ability to satisfy are likely to be the result of the previous experience of foods of similar tastes and textures, and previous relations between these tastes and textures and subsequent experiences of fullness and satisfaction. All stimuli were composed of common foods - milk and sugar, that will have frequently been previously experienced and judged. The increased rating of fattiness with increasing intensities of sweetness is also likely to be a result of previous experience. High levels of sweetness are commonly experienced in association with high levels of dietary fat content (Drewnowski and Greenwood, 1983). The mis-perception of increasing levels of fat with increasing intensities of sweetness has been previously reported (Monneuse, Bellisle and Louis-Sylvestre, 1991a). The clear distinction between stimuli of 0% sweetness and stimuli of higher sweetness intensities may also be attributed to previous experience. The addition of sweetness to a normally unsweetened food would be expected to be more pronounced than the addition of sweetness to an often sweetened food (Frijters, 1987).

Increasing levels of dietary fat content were rated as increasingly more pleasant. This gradual increase in pleasantness with increasing fat content has been frequently previously reported (Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1985; Drewnowski and Greenwood, 1983). Increasing levels of dietary fat content were also accurately rated as potentially more able to fill and potentially more able to satisfy. These effects are similar to those found in relation to sweetness intensity, and can be similarly understood as a result of a previous experience of foods of similar tastes and textures. Increasing levels of dietary fat content were also rated as increasingly more sweet. This is also likely to be an effect of experience. Stimuli of higher levels of dietary fat content (single cream, double cream) are likely to have been often previously experienced in association with sweetness. In contrast, stimuli of lower levels of dietary fat content (skimmed milk, whole milk), are more likely to have been often previously experienced unsweetened.

The many interactions between sweetness intensity and dietary fat content found in this study, are similarly likely to be based in previous experience. Specific interpretation and explanation of all interactions has been avoided due to the absence of clear patterns in the findings.

10.4.2. HIGH (AC) AND LOW (WC, NC) CONSUMERS OF ARTIFICIALLY-SWEETENED BEVERAGES and HIGH (AC, NC) AND LOW (WC) CONSUMERS OF SWEETENED BEVERAGES

No differences were found in this study between high and low consumers of artificially-sweetened beverages and no differences were found between high and low consumers of sweetened beverages in response to sweetness intensity and/or in response to dietary fat content. These findings suggests high and low consumers of artificially-sweetened beverages, and high and low consumers of sweetened beverages do not differ in responses to sweetness, to differing intensities of sweetness or to differing levels of dietary fat content. These findings are surprising.

High consumers of all sweetened beverages are self-selecting to consume high levels of sweetened foods. An increased preference for sweet foods would be expected in these consumers (e.g. Laeng, Berridge and Butter, 1993; Conner and Booth, 1988). Previous research has also suggested the repeated experience of foods to increase preferences (Pliner, Pelchat and Grabski, 1993; Pliner, 1982). A preference for sweetness following the repeated consumption of sweetened beverages has been found in some of the previous studies conducted (e.g. Addington, 1988, PhD thesis; Kanders, Lavin, Kowalchuk, Greenberg and Blackburn, 1988). Not all previous studies have found an increase in preference for sweetness however (e.g. Blackburn, Kanders, Lavin, Keller and Whately, 1997).

Preferences for and acceptance of differing sweetness intensities have not previously been investigated specifically in these consumers. The absence of effects here suggest that high consumers of artificially-sweetened beverages and high consumers of sweetened beverages have not habituated to sweetness. A high consumption of sweetness has previously not been associated with a habituation to sweetness (Tepper, Hartfiel and Schneider, 1996). Sweet taste has also previously been suggested to be very resistant to habituation in the short term (Schifferstein and Frijters, 1992) and to sensory specific satiety (Rolls, 1987). A lack of differences in responses to sweetness and to differing intensities of sweetness between consumers may be a result of similar preferences for sweetness in all consumers, and similar levels of consumption of <u>all</u> sweetened foods. Only consumption levels of sweetened beverages were measured in this study.

Previous research has also suggested an increased preference for and consumption of dietary fat following the repeated consumption of artificial sweeteners (e.g. Naismith and Rhodes, 1995; Porikos, Hesser and van Itallie, 1982). An increased preference for and consumption of dietary fat following the repeated consumption of artificial sweeteners, however has also not been found in other studies (e.g. Blackburn, Kanders, Lavin, Keller and Whately, 1997; Gatenby, Aaron, Jack and Mela, 1997; Lavin, French and Read, 1997). An absence of differences in preferences for dietary fat between consumers has previously been explained as a result of a very strict control of fat intake in certain consumers (Lavin, French and Read, 1997, and see de Castro, 1995). It is possible that fat consumption is highly controlled in the high consumers of artificially-sweetened beverages in this study.

The absence of effects both of sweetness intensity and of dietary fat content however, may alternatively be explained as a result of the methodology used. The taste-testing paradigm has previously been demonstrated as a valuable tool for investigating preferences for sweetness and fat (e.g. Drewnowski, Halmi, Pierce, Gibbs and Smith, 1987; Drewnowski, Brunzell, Sande, Iverius and Greenwood, 1995; Drewnowski and Greenwood, 1983; Rodin, Moskowitz and Bray, 1976). The generalizability and validity of the measure however, is far from conclusive. Few studies have related preferences for sweetness and dietary fat in milk/sugar stimuli to preferences for sweetness and dietary fat in other food items. Responses to sweetness have been found to differ in differing solutions (Calvino, Garcia-Medina, Cometto-Muniz and Rodriguez, 1993), and responses to sweetness/fat combinations have been found to differ in liquid and solid stimuli (Drewnowski, Shrager, Lipsky, Stellar and Greenwood, 1989). Few studies have also found any association between preferences for sweetness and fat in milk/sugar stimuli and consumption levels of sweetness and dietary fat in the typical diet (Wurtman and Lieberman, 1987). Tepper, Hartfiel and Schneider (1996) found no association between preferences for sweetness and consumption levels of sweetened foods in the diet. Lukman (1998) found no association between preferences for levels of dietary fat in solution and consumption levels of fat in the diet. Even in comparing preferences for yoghurt/sugar stimuli or yoghurt/sweetener stimuli and ad-libitum intake of the same yoghurt/sugar stimuli or yoghurt/sweetener stimuli, only poor correlations have been found (Perez, Dalix, Guy-Grand and Bellisle, 1994; Monneuse, Bellisle and Louis-Sylvestre, 1991b). The absence of effects between consumers in this study may be a result of the limited validity of the measure used.

A small difference was found between consumers in ratings of sweetness. AC consumers rated two of the sweetness intensities (5% and 10%) significantly more sweet than NC consumers. This difference is small and unsystematic, and also currently remains unexplained theoretically. This difference however is the opposite of a response to sweetness that would suggest a habituation to sweetness in high consumers of artificially-sweetened beverages. If sweetness were habituated to in the high consumers, high consumers would be expected to rate all stimuli as <u>less</u> sweet than low consumers. This difference is also unlikely to have been influential in ratings in any of the other scales. In the scale of pleasantness, no patterns were found. In the scales of fattiness, potential ability to fill and potential ability to satisfy, clear and systematic patterns were found throughout. Differing responses between AC and NC consumers for stimuli of 5% and 10% sweetness intensity would be obvious.

Effects in this study are unlikely to have been influenced by differences between consumers in artificially-sweetened beverage consumption. No clear differences or similarities were found between consumers differing in artificially-sweetened beverage consumption (male and female AC consumers), or between consumers differing in sweetened beverage consumption (female WC, AC and NC consumers).

10.4.3. ADDITIONAL FINDINGS

Three other findings in this study are worthy of mention. Firstly, significant differences were found between genders in scales of pleasantness, fattiness, potential ability to fill and potential ability to satisfy. Males rated all stimuli more pleasant, more fatty, potentially more filling, and potentially more satisfying than females. This overall increase in ratings by males has been reported previously (Monneuse, Bellisle and Louis-Sylvestre, 1991a), but currently remains unexplained.

Secondly, differences were also found between genders in the scale of pleasantness in response to the differing intensities of sweetness. Maximal pleasantness in male participants was achieved at the 15% sweetness intensity, whereas maximal pleasantness in female participants was achieved at the 5% sweetness intensity. A preference for increased amounts of sweetness in males compared to females has been previously suggested (Perez, Dalix, Guy-Grand and Bellisle, 1994; Monneuse, Bellisle and Louis-Sylvestre, 1991a). Female participants, in this study were also less able to discriminate the higher intensities of sweetness. Associations have previously been reported between perceptions of sweetness intensity and sweetness preferences (e.g. Geiselman, Smith, Williamson, Champagne, Bray and Ryan, 1998). The effect in this study however may be a result of a decreased preference and a consequent decreased willingness to taste the more intense stimuli.

Thirdly, differences were also found between genders in the scale of pleasantness in response to the differing levels of dietary fat content. Female participants rated increasing levels of dietary fat to be increasingly pleasant, males rated all levels of dietary fat content to be equally pleasant. Increasing preferences for increasing levels of fat have been previously reported in women (e.g. Monneuse, Bellisle and Louis-Sylvestre, 1991a; Drewnowski and Greenwood, 1983).

10.5. SUMMARY

In summary, this study uncovered no differences between high and low consumers of artificially-sweetened beverages in responses to sweetness, sweetness intensity and dietary fat content. This absence of differences has been found despite the reported detection and experience of all sensory manipulations. The absence of differences between high and low consumers of artificially-sweetened beverages in this study suggests either consumers do not differ in response to sweetness, differing intensities of sweetness or to differing levels of dietary fat content, or that the differences existing were not detected in this study. The generalizability and validity of the method used in this study - a taste-test of milk/sugar stimuli, are far from conclusive. Preferences for sweetness and preferences for dietary fat content between high and low consumers of artificially-sweetened beverages will be re-investigated in this thesis using more naturalistic methods in Chapter 12. Sweetness intensity can not be investigated using naturalistic methods. Whilst the methodology of this study is severely questioned however, limited evidence is available from this study suggesting the high consumption of artificially-sweetened beverages does not result in a habituation to sweetness.

Chapter 11.
STUDY 7:
UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE AND APPETITE CONTROL:
GENERAL EATING ATTITUDES AND BEHAVIOURS

Studies 3, 4, 5, and 6, have investigated the effects of the habitual consumption of sweetness without energy on appetite. This chapter and the following chapter investigate the effects of the habitual consumption of sweetness without energy on appetite and appetite control.

ABSTRACT

This study investigates general eating attitudes and behaviours in male and female, high and low consumers of artificially-sweetened beverages. Levels of artificially-sweetened beverage consumption, B.M.I. and various eating attitudes and behaviours were measured by self-report questionnaire (Drinks F.F.Q., D.E.B.Q., Y.E.P.Q., E.D.I.). Associations were found in all participants, but were more marked in female than male participants. The high consumption of artificially-sweetened beverages was found to be associated with high levels of B.M.I., high levels of restrained eating and high levels of highly cognitively controlled, disinhibited and disordered eating. These findings suggest an association between the high consumption of sweetness without energy, high levels of appetite and high levels of cognitive appetite control. Differences between high and low consumers were predicted in this study by levels of B.M.I. and weight preoccupation (E.D.I.). The associations above thus, are most appropriately explained as a result of associations with the deliberate self-selection of a high consumption of artificially-sweetened beverages. Effects of the habitual uncoupling of sweetness and energy however, may still exist.

11.1. INTRODUCTION

As discussed in Chapter 3, uncoupling sweetness and energy in habitual high consumers of artificial sweeteners may have effects on overall levels of appetite. As a result of the habitual uncoupling of sweetness and energy, the habitual consumption of less energy, and associations with the habitual high consumption of artificial sweeteners, the habitual consumption of sweetness without energy may result in increases in appetite.

As discussed in Chapter 3, uncoupling sweetness and energy in habitual high consumers of artificial sweeteners may also have a number of effects on appetite control. By the habitual uncoupling of sweetness and energy, the habitual consumption of sweetness without energy may result either in a less strict control of appetite or increases in the use of non-biological controls of appetite. By the habitual consumption of artificial sweeteners, or rather the knowledge of that consumption, the habitual consumption of sweetness without energy may result in increases in the cognitive control of appetite and increased tendencies toward disordered eating. By associations with the deliberate self-selection of artificial sweeteners, the habitual consumption of artificial sweeteners may be associated with high levels of B.M.I., high levels of weight concern, and a high cognitive control of appetite.

The use of differing controls of appetite have previously been widely demonstrated and reported within the general population (e.g. Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998; de Castro, 1997b; and see Schlundt, 1995). Biological controls of appetite are predominantly described as hunger and thirst (Logue, 1986). Non-biological controls may be broadly described as either cognitive (eating in response to cognitions), emotional (eating in response to emotions e.g. depression, anxiety, elation) or environmental (eating in response to environmental stimuli e.g. time, place, society) (Altschul, 1993; Schlundt, Hill, Sbrocco, Pope-Cordle and Kasser, 1990). Eating in response to differing stimuli will result in the development of differing eating patterns and eating behaviours (Mela and Rogers, 1998; Schlundt, 1995). A predominantly cognitive control of appetite, for example, would be expected to result in a restrained and tightly controlled eating pattern, characterized by highly controlled, restrictive behaviours.

Increases in appetite or a less strict control of appetite can be suggested by the measurement of actual food consumption (in the laboratory or naturalistically) or more indirectly by the measurement of B.M.I. (see Wolper, Heshka and Heymsfield, 1995). The use of non-biological controls of appetite can be investigated by measuring various relevant attitudes and behaviours. Attitudes and behaviours relevant to the control of appetite can be investigated by self-report questionnaire (see Schlundt, 1995), and can be investigated naturalistically, by specialized self-report food diaries (e.g. de Castro, 1994a).

Levels of appetite and general eating attitudes and behaviours will be investigated in this study by self-reported B.M.I. and several self-report questionnaires. Increased appetite and specific eating behaviours are also investigated naturalistically in Study 8.

11.1.1. AIMS

This study aims to investigate general eating attitudes and behaviours in habitual high and low consumers of sweetness without energy. General eating attitudes and behaviours will be investigated by self-report questionnaire. Habitual high and low consumers of sweetness without energy will be defined as detailed in Chapter 7. Low consumers will additionally be defined either as high consumers of naturally-sweetened beverages or high consumers of non-sweet/low energy beverages (see Chapter 9).

11.2. METHOD

11.2.1. DESIGN

The study is a questionnaire study investigating levels of consumption of artificially-sweetened beverages, naturally-sweetened beverages, and non-sweet/low energy beverages, B.M.I. and various general eating attitudes and behaviours.

11.2.2. QUESTIONNAIRES

Levels of consumption of artificially-sweetened beverages, naturally-sweetened beverages, and non-sweet/low energy beverages were measured using a Drinks Food Frequency Questionnaire. B.M.I. was measured in the demographics section of the Drinks F.F.Q. General eating attitudes and behaviours were measured using three questionnaires - the Dutch Eating Behaviors Questionnaire (D.E.B.Q.) (van Strien, Frijters, Bergers and Defares, 1986), the Yale Eating Patterns Questionnaire (Y.E.P.Q.) (Kristeller and Rodin, 1989), and the Eating Disorder Inventory (E.D.I.) (Garner, Olmstead and Polivy, 1983). These questionnaires were selected as reliable, validated questionnaires intended for use in non-clinical populations. These specific questionnaires were chosen for the study to allow consideration of a broad number of eating attitudes and behaviours, but also to limit the number of question items all respondents were asked to complete.

The full questionnaire set is displayed in Appendix 11.1. The full set could be completed in approximately 40 min. Piloting was carried out prior to distribution.

11.2.2.1. Drinks Food Frequency Questionnaire

The Drinks Food Frequency Questionnaire was an open-response F.F.Q. questioning consumption levels of various differing drink types. Each respondent was asked to indicate the quantity of each drink type consumed, either on a daily or weekly basis depending on applicability (e.g. regular carbonated drinks - .... cans per day / week). Consumption levels of artificially-sweetened beverages were investigated by questioning consumption levels of 'diet/reduced-sugar/sugar-free squash', 'diet carbonated drinks' and 'tea or coffee sweetened with artificial sweeteners'. Consumption levels of naturally-sweetened beverages were investigated by questioning consumption levels of 'tea or coffee sweetened with sugar', 'fruit juice', 'regular carbonated drinks', 'regular squash', 'hot chocolate' and 'milkshake'. Consumption levels of non-sweet/low energy beverages were investigated by questioning consumption levels of 'water' and 'unsweetened tea or coffee'.

The Drinks Food Frequency Questionnaire was developed following Study 2, and was also used as a recruitment questionnaire in all studies investigating the habitual consumption of sweetness without energy (excepting this study), in this thesis (see Appendix 8.1).

11.2.2.2. Demographics

The demographics investigated in this study were gender, (height, weight,) and calculated B.M.I. Age, smoking status, vegetarianism and current dieting status were also questioned, but were for recruitment purposes only and were not included in the study.

11.2.2.3. Dutch Eating Behaviors Questionnaire (D.E.B.Q.) (van Strien, Frijters, Bergers and Defares, 1986)

The D.E.B.Q. uses 33 items to measure three scales of eating behaviour:- Restrained Eating (10 items); Emotional Eating (13 items); and External Eating (10 items). All items are responded to on a 5-point response format (never, seldom, sometimes, often, very often). All responses are scored (never = 1 - very often = 5), and a score per scale of eating behaviour is achieved per respondent as a summation of all scores for all appropriate items. The reliability and validity of the questionnaire were established at the time of development on a number of differing non-clinical populations (van Strien, Frijters, Bergers and Defares, 1986) and has also been subsequently verified by other studies (e.g. Wardle, 1987c, see Schlundt, 1995).

11.2.2.4. Yale Eating Patterns Questionnaire (Y.E.P.Q.) (Kristeller and Rodin, 1989)

The Y.E.P.Q. uses 70 items to measure nine subscales of eating behaviour:- Uninhibited (9 items); Oversnacking (12 items); Bingeing (13 items); Dieting (5 items); Satiation - Full (5 items); Satiation - Nausea (8 items); Satiation - Guilt (6 items); Attribute Overweight to Physical Factors (10 items); and Attribute Overweight to Emotional Factors (2 items). All items for the subscales of Satiation - Full, Nausea and Guilt were responded to on a 4-point response format (very important, quite important, not very important, not at all important; scored: very important = 3 - not at all important = 0). All other items were responded to on a 5-point response format (never, seldom, sometimes, often, very often; scored: never = 1 - very often = 5). A score per subscale is achieved per respondent as a summation of all scores for all appropriate items. All subscales were then used to classify individuals on six scales of eating behaviour:- tendency toward Uninhibited Eating; Uninterested Eating; Bingeing; Guilty Dieting; High Self-Monitored Eating; and Low Self-Monitored Eating. As defined in the original work:

Uninhibited Eating is characterized by high levels of uninhibited eating, high levels of snacking, low levels of dieting, the use of moderate rather than extreme satiation cues, a low use of guilt as a satiation cue, and the high rating of physiology as important in weight control but an awareness of the possible effects of emotions;

Uninterested Eating is similar to uninhibited eating (low levels of dieting, a low use of guilt as a satiation cue, the high rating of physiology as important in weight control but an awareness of the possible effects of emotions), but is also defined by a lack of interest in food - low levels of snacking and bingeing;

Bingeing is characterized by high levels of bingeing, high levels of snacking, high levels of dieting, a high use of guilt as a satiation cue, and the rating of emotional upset as very important in weight control;

Guilty Dieting is characterized by very low levels of uninhibited eating, a high use of guilt as a satiation cue as opposed to internal cues, and the rating of emotional upset as very important in weight control;

High Self-Monitored Eating is characterized by a high level of self control around food intake, the use of moderate and extreme internal satiation cues and the rating neither of physiology nor emotions as important in weight control;

Low Self-Monitored Eating is similar to guilty dieting (the high use of guilt as a satiation cue as opposed to internal cues), but is also characterized by a failure to rate emotions as important in weight control and some disinhibited eating - snacking and bingeing.

The reliability and validity of the questionnaire were established at the time of development (Kristeller and Rodin, 1989).

11.2.2.5. Eating Disorders Inventory (E.D.I.) (Garner, Olmstead and Polivy, 1983)

The E.D.I. was originally designed to screen individuals for eating disorders (see Stunkard, 1997 for a review of eating disorders). The questionnaire uses 64 items to measure three subscales of eating attitudes and behaviours:- Drive for Thinness (7 items); Bulimia (7 items); and Body Dissatisfaction (9 items); and five subscales of personality, characteristic of individuals with eating disorders:- Ineffectiveness (9 items); Perfectionism (7 items); Interpersonal Distrust (7 items); Interoceptive Awareness (10 items); and Maturity Fears (8 items). All items are responded to on a 6-point response format (always, usually, often, sometimes, rarely, never). All responses are scored (most eating disordered response = 3, adjacent response = 2, adjacent response = 1, least eating disordered three responses = 0), and a score per subscale is achieved per respondent as a summation of all scores for all appropriate items. All subscales are then used to classify individuals on four scales of eating attitudes and behaviours:- tendency toward Body Dissatisfaction, Weight

Preoccupation, Anorexia Nervosa Restrictor Type, and Anorexia Nervosa Bulimia Type. As defined in the original work:

Body Dissatisfaction is characterized by high levels of body dissatisfaction;

Weight Preoccupation is characterized by high levels of: body dissatisfaction, drive for thinness, and uncontrolled binge eating (bulimia);

Anorexia Nervosa Restrictor Type is characterized by high levels of: body dissatisfaction, drive for thinness, feelings of ineffectiveness, perfectionism, interpersonal distrust, interoceptive awareness, and maturity fears.

Anorexia Nervosa Bulimia Type is characterized as Anorexia Nervosa Restrictor Type, but also includes high levels of uncontrolled binge eating (bulimia).

Bulimia as an eating disorder is not classified separately, but is considered indistinct in symptomatology from Anorexia Nervosa - Bulimia Type (Garner, Olmstead and Polivy, 1983). The reliability and validity of the questionnaire were established at the time of development (Garner, Olmstead and Polivy, 1983) and have also been supported by subsequent studies (see Williamson, Anderson, Jackman and Jackson, 1995).

11.2.3. QUESTIONNAIRE DISTRIBUTION

The full questionnaire set was distributed among 250 individuals responding to advertisements for 'Volunteers for a Nutrition Study', 'High Consumers of Diet Drinks', or 'High Consumers of Soft Drinks'; and among a convenience sample of 450 staff and students of the University of Leeds. In total, 248 out of 700 (35.4%) full questionnaire sets were returned completed and could be used.

11.2.4. ANALYSIS

11.2.4.1. Levels of Beverage Consumption

Levels of consumption of artificially-sweetened beverages, naturally-sweetened beverages, and non-sweet/low energy beverages were analysed as quantity consumed per day (ml/day). This was calculated by summation of the reported quantity consumed of all drinks of each type (see section 11.2.2.1). As detailed in Chapter 7, high consumers of sweetness without energy were defined as consuming ≥ 825 ml (artificially-sweetened beverages)/day, low consumers were defined as consuming 0 ml (artificially-sweetened beverages)/day. As detailed in Chapter 9, low consumers of sweetness without energy were also defined as consuming ≥ 825 ml (naturally-sweetened beverages)/day or ≥ 825 ml (non-sweet/low energy beverages)/day. All respondents consuming 0ml (artificially-sweetened beverages)/ day, ≥ 825 ml (naturally-sweetened beverages)/day and ≥ 825 ml (non-sweet/low energy beverages)/day were defined as consumers of the beverage type of which they consumed the most. All other respondents were excluded from the study.

11.2.4.2. B.M.I.

B.M.I. was calculated from self-reports of height and weight (weight(kg) / height(m)^2).

11.2.4.3. Eating Attitudes and Behaviours

All construct questionnaires were scored as detailed in section 11.2.2, resulting in a score per respondent for each scale of eating behaviour. In total, thirteen scales were used - D.E.B.Q. - Restrained Eating, Emotional Eating, External Eating; Y.E.P.Q. - Uninhibited Eating, Uninterested Eating, Bingeing, Guilty Dieting, High Self-Monitored Eating, Low Self-Monitored Eating; E.D.I. - Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type, Anorexia Nervosa Bulimia Type. For each scale, an overall score was only achieved if all items on that scale were responded to. Incomplete item response for any scale resulted in missing data for that whole scale. In total, data was missing for 208 out of 3224 (6.5%) single scale scores.

Groups of consumers were compared on B.M.I. using 2-way ANOVA (gender by consumer). Male and female respondents were also analysed separately using 1-way ANOVA. Groups of high consumers of artificially-sweetened beverages, high consumers of naturally-sweetened beverages and high consumers of non-sweet/low energy beverages were compared on all scales of eating attitudes and behaviours using 2-way MANOVA (gender by consumer). Male and female respondents were also analysed separately using 1-way MANOVA. Significant MANOVA (univariate results) and ANOVA results were investigated using Student-Newman-Keuls t-tests.

The high consumption of artificially-sweetened beverages compared to the low consumption of artificially-sweetened beverages (high consumption of naturally-sweetened beverages or non-sweet/low energy beverages), was also investigated using Logistic Regression. This analysis was conducted to highlight the importance of all eating attitudes and behaviours in the high consumption of artificially-sweetened beverages. Logistic Regression was conducted in preference to other types of regressional analyses, due to the dichotomy of artificially-sweetened beverage consumption (high/low), and the probable inter-relation of many of the eating attitude and behaviour scales. Logistic Regression was conducted only on all respondents together, due to the small sample sizes of separate groups of male and female respondents.

All missing data was recognised as missing by the computer. None were replaced.

11.3 RESULTS

11.3.1. LEVELS OF BEVERAGE CONSUMPTION

In total, 120 of the 248 (48.4%) completed questionnaires were used in the study:- 51 high consumers of artificially-sweetened beverages (AC consumers) - 10 males and 41 females, 36 low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC consumers) - 14 males and 22 females, and 33 low consumers of artificially-sweetened beverages but high consumers of non-sweet/low energy beverages (WC consumers) - 7 males and 26 females. Consumption levels of all beverages per group (mean (st. dev.) are displayed in Table 11.1.

Table 11.1: Consumption Levels of All Beverages per Group (mean (st. dev.) per Day.

Participants	Beverage Consumption (ml/day)		
	Non-Sweet	Artificially-Sweet	Naturally-Sweet
WC - Male (N=7)	1551.0 (412.8)	0.0 (0.0)	157.3 (178.1)
WC - Female (N=26)	1650.5 (561.0)	0.0 (0.0)	339.7 (220.0)
AC - Male (N=10)	614.3 (741.6)	1484.6 (488.3)	284.3 (302.7)
AC - Female (N=41)	536.8 (866.3)	1690.0 (905.2)	376.4 (485.2)
NC - Male (N=14)	68.4 (239.8)	0.0 (0.0)	1609.0 (709.8)
NC - Female (N=22)	481.8 (524.2)	0.0 (0.0)	1437.9 (382.1)

Participants: WC Consumers = High Consumers of Non-Sweet/Low Energy Beverages; AC Consumers = High Consumers of Artificially-Sweetened Beverages; NC Consumers = High Consumers of Naturally-Sweetened Beverages.

11.3.2. B.M.I.

11.3.2.1. All Respondents

No significant differences were found between genders ($F(1,116)=0.11$, $p=0.75$). Significant differences were found between consumers ($F(2,116)=12.39$, $p<0.001$). AC consumers reported significantly higher levels of B.M.I. than WC ($t(79)=-3.83$, $p<0.001$) and NC consumers ($t(65)=3.86$, $p<0.001$). No differences were found between WC and NC consumers ($t(84)=-0.04$, $p=0.97$). No interaction was found ($F(2,116)=0.02$, $p=0.98$). Levels of B.M.I. are shown in Appendix 11.2.

11.3.2.2. Male Respondents

Significant differences were found between consumers ($F(2,29)=5.73$, $p=0.01$). AC consumers reported higher levels of B.M.I. than WC ($t(14)=-2.48$, $p=0.03$) and NC consumers ($t(18)=3.04$, $p=0.01$). No differences were found between WC and NC consumers ($t(22)=0.10$, $p=0.92$).

11.3.2.3. Female Respondents

Significant differences were found between consumers (F(2,86)=8.02, p=0.001). AC consumers reported higher levels of B.M.I. than WC (t(63)=-3.19, p=0.002) and NC consumers (t(45)=2.86, p=0.01). No differences were found between WC and NC consumers (t(60)=-0.05, p=0.96).

11.3.3. EATING ATTITUDES AND BEHAVIOURS

11.3.3.1. All Respondents

No significant difference was found between genders (F(13,80)=0.69, p=0.76). A significant difference was found between consumers (F(26,162)=2.34, p=0.001). Differences between consumers were found in scales of D.E.B.Q.- Restrained Eating (F(2,92)=14.55, p<0.001), Y.E.P.Q.- Bingeing (F(2,92)=3.91, p=0.02), E.D.I.- Body Dissatisfaction (F(2,92)=10.60, p<0.001), E.D.I.- Weight Preoccupation (F(2,92)=11.20, p<0.001), E.D.I.- Anorexia Nervosa Restrictor Type (F(2,92)=6.58, p=0.002), E.D.I.- Anorexia Nervosa Bulimia Type (F(2,92)=5.27, p=0.01). AC consumers reported higher levels of Restrained Eating, and higher tendencies toward Bingeing, Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type, and Anorexia Nervosa Bulimia Type than WC consumers (smallest t(70)=2.19, p=0.03) and NC (smallest t(71)=2.72, p=0.01). No differences were found between WC and NC consumers (largest t(49)=1.41, p=0.17). No significant differences were found in other scales (largest F(2,92)=2.58, p=0.08). Scores on All Eating Attitude and Behaviour Scales are shown in Appendix 11.3.

11.3.3.2. Male Respondents

A significant difference was found between consumers (F(26,38)=3.88, p=0.003). Differences were found in scales of D.E.B.Q.- Restrained Eating (F(2,19)=9.60, p=0.001), E.D.I.- Body Dissatisfaction (F(2,19)=5.32, p=0.02), E.D.I.- Weight Preoccupation (F(2,19)=5.97, p=0.01), E.D.I.- Anorexia Nervosa Restrictor Type (F(2,19)=5.38, p=0.01), E.D.I.- Anorexia Nervosa Bulimia Type (F(2,19)=3.53, p=0.05). AC consumers reported higher levels of Restrained Eating, and higher tendencies toward Body Dissatisfaction and Weight Preoccupation, than NC consumers (smallest t(16)=2.93, p=0.01). AC consumers reported higher tendencies toward Anorexia Nervosa Restrictor Type and Anorexia Nervosa Bulimia Type than WC consumers (smallest t(11)=-3.94, p=0.002). No differences were found between WC and NC consumers (largest t(11)=-1.38, p=0.20).

11.3.3.3. Female Respondents

A significant difference was found between consumers (F(26,124)=1.70, p=0.05). Differences were found in scales of D.E.B.Q.- Restrained Eating (F(2,73)=8.29, p=0.001), Y.E.P.Q.- Bingeing ($F(2,73)=4.30$, $p=0.02$), E.D.I.- Body Dissatisfaction ($F(2,73)=7.82$, $p=0.001$), E.D.I.- Weight Preoccupation ($F(2,73)=9.71$, $p<0.001$), E.D.I.- Anorexia Nervosa Restrictor Type ($F(2,73)=3.41$, $p=0.04$), E.D.I.- Anorexia Nervosa Bulimia Type ($F(2,73)=3.67$, $p=0.03$). AC consumers reported higher levels of Restrained Eating, and higher tendencies toward Bingeing, Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type and Anorexia Nervosa Bulimia Type, than WC consumers (smallest $t(57)=-2.00$, $p=0.05$) and NC consumers (smallest $t(53)=2.12$, $p=0.04$). No differences were found between WC and NC consumers (largest $t(36)=1.10$, $p=0.28$).

11.3.4. IMPORTANCE OF B.M.I., ALL EATING ATTITUDES and BEHAVIOURS.

11.3.4.1. All Respondents

In all respondents, on entering B.M.I. and all eating attitude and behaviour scales into a logistic regression, 84.2% of respondents could be correctly classified as high (AC) or low (WC, NC) consumers of artificially-sweetened beverages by the regression equation ($\chi^2(14)=54.92$, $p<0.001$). By consumer group, 88% of high consumers of artificially-sweetened beverages were correctly classified and 80% of low consumers (WC, NC) were correctly classified. Of all eating attitude and behaviour scales, significant predictors of artificially-sweetened beverage consumption were B.M.I. ($B(1)=0.29$, $p=0.004$) and E.D.I.- Weight Preoccupation ($B(1)=-0.16$, $p=0.056$) (marginally significant). The importance of all eating attitude and behaviour scales in the regression equation are shown in Table 11.2.

Table 11.2: Slope (B), Standard Errors and the Significance of All Eating Attitude and Behaviour Scales in the Regression Equation (N=95).

Variable	B	Standard Error	Significance
D.E.B.Q.- Restrained Eating	0.0633	0.0639	0.3219
D.E.B.Q.- Emotional Eating	-0.0662	0.0443	0.1352
D.E.B.Q.- External Eating	-0.1005	0.0784	0.1998
Y.E.P.Q.- Uninhibited Eating	0.1194	0.0711	0.0933
Y.E.P.Q.- Uninterested Eating	-0.0005	0.1991	0.9979
Y.E.P.Q.- Bingeing	0.1158	0.1326	0.3826
Y.E.P.Q.- Guilty Dieting	0.0826	0.0801	0.3024
Y.E.P.Q.- High Self-Monitored Eating	0.0816	0.1875	0.6636
Y.E.P.Q.- Low Self-Monitored Eating	-0.0309	0.1452	0.8317
E.D.I.- Body Dissatisfaction	-0.3022	0.1903	0.1123
E.D.I.- Weight Preoccupation	**0.3123**	**0.1631**	**0.0556**
E.D.I.- Anorexia Nervosa Restrictor	0.2468	0.1588	0.1203
E.D.I.- Anorexia Nervosa Bulimia	-0.2600	0.1558	0.0952
B.M.I.	**0.2912**	**0.0996**	**0.0035**
Constant	-6.7131	4.333	0.1213

11.4. DISCUSSION

In analysing all respondents, associations were found in this study, between the high consumption of artificially-sweetened beverages, B.M.I. and various general eating attitudes and behaviours. Associations were found in all respondents, in male respondents and in female respondents, and were similar in all respondent groups, but were more marked in female than in male respondents.

11.4.1. DIFFERENCES BETWEEN HIGH (AC) AND LOW (WC, NC) CONSUMERS OF ARTIFICIALLY-SWEETENED BEVERAGES

In all respondents, the main findings of this study are:

- High consumers reported significantly higher levels of B.M.I., Restrained Eating, and significantly higher tendencies toward Bingeing, Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type, Anorexia Nervosa Bulimia Type, than low consumers.
- Differences between high and low consumers of artificially-sweetened beverages could be predicted in a logistic regression equation by B.M.I. and E.D.I.- Weight Preoccupation.

Differences between high and low consumers of artificially-sweetened beverages in this study are clear. High consumers reported higher levels of B.M.I., higher levels of Restrained Eating, and higher tendencies toward Bingeing, Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type and Anorexia Nervosa Bulimia Type. These findings are suggestive of an association between the high consumption of artificially-sweetened beverages and an increased appetite and an increased use of non-biological controls of appetite.

An increased appetite is suggested by higher levels of B.M.I. This finding is unsurprising. High levels of B.M.I. in association with the consumption of artificially-sweetened beverages and many other artificially-sweetened products have been previously widely reported (e.g. Stellman and Garfinkel, 1986; Parham and Parham, 1980).

A higher use of non-biological controls of appetite is demonstrated by higher levels of restrained eating. These results again are unsurprising. Increased levels of dietary restraint have frequently been reported in high consumers of artificially-sweetened beverages and other artificially-sweetened products (e.g. Schoeller, Shay and Kushner, 1997; Alexander and Tepper, 1995). High levels of restrained and highly controlled eating are also supported in this study by higher tendencies toward Anorexia Nervosa Restrictor type and Anorexia Nervosa Bulimia type, in the high consumers.

High consumption levels of artificially-sweetened beverages in this study, are also associated with the increased use of maladaptive controls of appetite. The maladaptive control of appetite is demonstrated by higher tendencies toward body dissatisfaction, weight preoccupation, Anorexia Nervosa Restrictor type and Anorexia Nervosa Bulimia type. An association between the high consumption of artificially-sweetened beverages or any other artificially-sweetened products and a tendency toward disordered eating has not been previously reported. These results however are not surprising. Eating disorders are considered to differ from normal eating patterns and behaviours not in type but only in degree (Polivy, 1996; Wardle, 1987b). Anorexia Nervosa Restrictor type is considered to be an extension of high levels of restraint and highly controlled eating (Polivy and Herman, 1985). Anorexia Nervosa Bulimia type and Bulimia are considered to be an extension of high levels of restraint and highly controlled eating interspersed with high levels of disinhibited and uncontrolled eating (Wardle, 1987a; Polivy and Herman, 1985). The increased tendency toward disordered eating found in this study, may be indicative of no more than extreme high levels of restraint and highly controlled eating and extreme levels of disinhibited and uncontrolled eating. This study it should be noted, measured only a tendency toward disordered eating, not disordered eating itself (see Garner, Olmstead and Polivy, 1983). A tendency toward disordered eating however, may easily become disordered eating (see Polivy, 1996). From this study, the high consumption of sweetness without energy, is associated with highly restrained eating and high tendencies toward a highly controlled, disinhibited and possibly disordered eating style. These findings suggested the high consumption of artificially-sweetened beverages to be associated with the high use of cognitive controls of appetite.

Considering the regressional analyses however, the high consumption of artificially-sweetened beverages compared to the low consumption of artificially-sweetened beverages but high consumption of naturally-sweetened beverages or non-sweet/low energy beverages, was significantly predicted by levels of B.M.I. and levels of weight preoccupation: differences found between high and low consumers of artificially-sweetened beverages can be explained by differences in B.M.I., differences in weight preoccupation, and the inter-relations between B.M.I., weight preoccupation and all other scales of appetite control. The association between the high consumption of artificially-sweetened beverages, increases in appetite and the increased use of cognitive controls of appetite thus, would appear to be not associated with the high consumption of artificially-sweetened beverages specifically, but with the high consumption of artificially-sweetened beverages as an artificially-sweetened product - a product believed to aid dietary and weight control. An association between the high consumption of artificially-sweetened beverages, artificially-sweetened products, B.M.I. and weight preoccupation is unsurprising. Similar associations have been frequently reported (e.g. Alexander and Tepper, 1995; Nabors and Lemieux, 1993). This finding however, suggests the associations found in this study between the habitual consumption of sweetness without energy and high levels of B.M.I. and the cognitive control of appetite, are unlikely to be an effect of the habitual uncoupling of sweetness and energy. These associations are much more appropriately explained as a result of associations with the deliberate self-selection of a high consumption of artificial sweeteners. Effects of the habitual uncoupling of sweetness and energy however, may still exist.

It is also important to note however, that whilst associations were found between consumption levels of artificially-sweetened beverages, B.M.I., and weight preoccupation, or between consumption levels of artificially-sweetened beverages, increases in appetite and increases in the use of cognitive controls, causality can not be inferred.

11.4.2. MALE AND FEMALE RESPONDENTS

Of additional interest, whilst similar responses were found in all respondents and in male and female respondents separately, effects were more marked in the female respondents.

Differences in the degree of effects in male and female respondents in similar studies of eating behaviours have been previously reported (see Rolls, Fedoroff and Guthrie, 1991). These differences may be explained both by actual differences between genders and by differences between the genders in reporting. Considering actual differences, the prevalence of the use of cognitive controls of appetite is reported to be much less in males than in females (Tepper, 1992; Wardle, Marsland, Sheikh, Quinn, Fedoroff and Ogden, 1992). Furthermore, whilst logistic regressional analyses could not be conducted on the single gender data, if the differences between high and low consumers in eating attitudes and behaviours are considered to be a result of differences in B.M.I. and weight preoccupation, males are also reported to be less preoccupied by weight than females (Rolls, Fedoroff and Guthrie, 1991). Differences between genders in concerns about weight however, particularly in young populations is becoming quite small (see Alexander and Tepper, 1995). Considering differences in reporting, differences between male and female respondents in self-report eating attitudes and behaviours may also be a result of social pressures. Concerns about eating, weight, etc., are considered normal or may even be expected in females; in males however, such concerns are less well accepted (Alexander and Tepper, 1995). The lesser effects in the male respondents in this study, may be due to a lesser willingness to admit weight concerns. Differences in reporting between genders however, may also be masking some of the differences between genders. In self-reports of B.M.I., females typically under-report their weights, males typically over-report their weights (Klesges, Mizes and Klesges, 1987). Considering the importance of B.M.I. in the regressional analyses, differences between male and female participants in this study may actually be greater than those uncovered.

Differences between male and female respondents in this study however, may also be purely methodological. Many more females were included in the analysis than males. Similar size effects will appear to be more significant in groups of larger numbers, due to increased statistical power (Howell, 1997). Groups of larger numbers will also have more influence in all analyses on all participants together (Howell, 1997).

11.4.2. ADDITIONAL FINDINGS

In addition to the above findings, some of the absent findings are worthy of mention. No differences were found between high and low consumers of artificially-sweetened beverages in scales of D.E.B.Q.- Emotional Eating, D.E.B.Q.- External Eating, Y.E.P.Q.- Uninhibited Eating, Y.E.P.Q.- Uninterested Eating, Y.E.P.Q.- Guilty Dieting, Y.E.P.Q.- Low Self-Monitored Eating or Y.E.P.Q.- High Self-Monitored Eating.

For scales of Y.E.P.Q.- Uninterested Eating and Y.E.P.Q.- Low Self-Monitored Eating, trends were found. High consumers of artificially-sweetened beverages reported lower tendencies toward Uninterested Eating, and Low Self-Monitored Eating, than low (WC, NC) consumers. These trends are considered supportive of the findings above. Associations have also previously been reported between a restrained and highly controlled eating style and a preoccupation with food (Fedoroff, Polivy and Herman, 1997; Wardle, 1987a; Polivy and Herman, 1985). Trends were also found in the scale of D.E.B.Q.- Emotional Eating. High consumers of artificially-sweetened beverages reported higher levels of Emotional Eating, than low (WC, NC) consumers. These findings again are unsurprising. High levels of emotional eating have been previously associated with high levels of B.M.I. (e.g. Blair, Lewis and Booth, 1990; Leon and Chamberlain, 1973), high levels of restrained eating (e.g. Wardle, Marsland, Sheikh, Quinn, Fedoroff and Ogden, 1992; van Strien, Frijters, Bergers and Defares, 1986), and high levels of restrained and disinhibited eating (Eldredge and Agras, 1996).

No differences were found in scales of D.E.B.Q.- External Eating, Y.E.P.Q.- Uninhibited Eating, Y.E.P.Q.- Guilty Dieting, or Y.E.P.Q.- High Self-Monitored Eating. No plausible explanations can be offered for these findings other than that there actually are no differences.

11.5. SUMMARY

In summary, this study has found differences between high and low consumers of artificially-sweetened beverages in self-report measures of B.M.I. and various eating attitudes and behaviours. High consumers of artificially-sweetened beverages reported higher levels of B.M.I., higher levels of restrained eating and higher tendencies toward highly cognitively controlled, disinhibited and disordered eating. These findings are suggestive of an association between the high consumption of sweetness without energy and possible increases in appetite and increases in the use of cognitive controls of appetite. Using regressional analyses, differences between high and low consumers of artificially-sweetened beverages were predicted by differences in B.M.I. and Weight Preoccupation (E.D.I.). This finding suggests that the associations found between the high consumption of artificially-sweetened beverages and the various eating attitudes and behaviours are most appropriately explained as a result of associations with the deliberate self-selection of artificial sweeteners. Effects are unlikely to be an effect of the habitual uncoupling of sweetness and energy. Effects of an uncoupling of sweetness and energy however, may still exist.

Chapter 12.

STUDY 8:

UNCOUPLING SWEETNESS AND ENERGY IN HABITUAL HIGH CONSUMERS: EFFECTS ON APPETITE AND APPETITE CONTROL:

SPECIFIC EATING BEHAVIOURS

ABSTRACT

This study investigates specific eating behaviours in male and female, high and low consumers of artificially-sweetened beverages. Specific eating behaviours were measured using specialized food diaries investigating overall quantities consumed, specific environmental stimuli relevant to the control of appetite, and specific reasons for meal initiation and termination. Effects were found in all participants, but were more marked in female than male participants. In overall quantities consumed, high consumers of artificially-sweetened beverages were found to consume a diet of lower energy density and higher levels of sweetness than low consumers. In measures of environmental stimuli relevant to the control of appetite, high consumers were influenced more than low consumers by the more cognitive environmental stimuli. In reasons for meal initiation and termination, no differences were found between consumers. These findings suggest the high consumption of artificially-sweetened beverages in male and females, to be associated with a more cognitive control of appetite compared to low consumers.

12.1. INTRODUCTION

In the previous study (Study 7), appetite and appetite control were investigated in high and low consumers of artificially-sweetened beverages, using self-report measures of B.M.I. and self-report questionnaires on general eating attitudes and behaviours. Appetite and appetite control can also be measured naturalistically.

Appetite is commonly measured naturalistically using self-report food diaries (Wolper, Heshka and Heymsfield, 1995). Food diaries have previously been reported as reliable and valid methodological tools for measuring food intake in the natural environment (see Wolper, Heshka and Heymsfield, 1995; de Castro, 1994), although considerations and precautions do need to be taken to ensure sustained accuracy and to prevent under-reporting (see Chapter 5, section 5.4.2.1). Appetite control can also be measured naturalistically, using specialized food diaries (e.g. de Castro, 1994a). Specialized food diaries extend the amount of information collected for each eating experience to include measures of various internal, emotional and environmental stimuli possibly relevant to appetite control (e.g. de Castro, 1994a). Numerous stimuli have previously been found to independently influence appetite (e.g. see de Castro, 1997b; de Castro, Brewer, Elmore and Orozco, 1990), and may indirectly or subconsciously control appetite (e.g. see Kim and Kissileff, 1995). More recently, specialized food diaries have also included measures of reasons for meal initiation and termination (e.g. Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998). The measurement of all reasons for meal initiation and termination also allows consideration of the more deliberate control of appetite. The reliability and validity of specialized food diaries have previously been reported (de Castro, 1994a), although again considerations and precautions do need to be taken to ensure sustained accuracy and to prevent under-reporting (see Chapter 5, section 5.4.2.1).

Appetite and appetite control will be measured in this study, using specialized food diaries. Appetite will be investigated by analysis of all foods consumed. Appetite control will be investigated by analysis of all environmental stimuli relevant to eating and by analysis of all reasons given for the initiation and termination of all meals. All foods consumed will also be analysed in this study, to allow the naturalistic investigation of preferences for sweetness and preferences for dietary fat between consumers. This extends the work on preferences for sweetness and preferences for dietary fat in Chapter 10.

12.1.1. AIMS

This study aims to investigate specific eating behaviours in high and low consumers of sweetness without energy. Specific eating behaviours will be investigated using specialized food diaries measuring overall quantities consumed, specific environmental stimuli relevant to the control of appetite, and specific reasons for meal initiation and termination. Quantities of sweetness consumed and quantities of dietary fat consumed will also be measured. Habitual high and low consumers of sweetness without energy will be defined as in Chapter 7. Low consumers will additionally be defined either as high consumers of naturally-sweetened beverages or high consumers of non sweet/low energy beverages (see Chapter 9).

12.2. METHOD

12.2.1. DESIGN

The study is a food-diary study investigating gender (2 levels), consumer type (3 levels) and various eating behaviours - overall quantity consumed, quantity of sweetness consumed, quantity of dietary fat consumed, numerous environmental stimuli relevant to appetite and appetite control, and the reasons given for meal initiation and termination.

12.2.2. CONSUMERS

Three independent groups of consumers participated in the study - habitual high consumers of artificially-sweetened beverages (AC), habitual low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC), and habitual low consumers of artificially-sweetened beverages but high consumers of non-sweet/ low energy beverages (WC). Habitual high consumers of artificially-sweetened beverages (AC) were required to be consuming ≥ 825 ml (artificially-sweetened beverages)/day. Habitual high consumers of naturally-sweetened beverages (NC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (naturally-sweetened beverages)/day. Habitual high consumers of non-sweet/low energy beverages (WC) were required to be consuming 0 ml (artificially-sweetened beverages)/day and ≥ 825 ml (non-sweet/low energy beverages)/day. Consumption levels of all beverages were reported by all participants on a self-report Drinks F.F.Q, (see Appendix 8.1), completed prior to inclusion in the study. Naturally-sweetened beverages were considered to be tea or coffee sweetened with natural sweeteners (sugar, honey), fruit juices, regular carbonated drinks, regular squash, hot chocolate, and milkshakes. Non-sweet/low energy beverages were considered to be unsweetened tea or coffee or water. Equal numbers of males and females participated in the study.

In total, 16 habitual high artificially-sweetened beverage consumers (AC)(8 male and 8 female), 16 habitual high naturally-sweetened beverage consumers (NC)(8 male and 8 female) and 16 habitual high non-sweet beverage consumers (WC)(8 male and 8 female) took part in the study. Prior to the start of the study, all participants were measured for calculation of B.M.I. and completed the D.E.B.Q., as a measure of dietary restraint. Consumer groups were matched as closely as possible on B.M.I. and dietary restraint (D.E.B.Q.-R.) scores. None of the participants were informed of the exact hypotheses of the study. Participant characteristics are displayed in Table 12.1.

Table 12.1: Participant Characteristics (mean (standard deviation))

Participants *	Beverage Consumption (ml/day)				
	Artificially-sweetened	Total Sweetened	Total	B.M.I. (kg/m^2)	D.E.B.Q.-R. score
WC - M (N=8)	0.0 (0.0)	167.9 (220.9)	2085.9 (690.9)	21.9 (1.7)	12.5 (3.3)
WC - F (N=8)	0.0 (0.0)	214.8 (142.2)	1480.5 (423.2)	22.5 (1.5)	22.1 (8.0)
AC - M (N=8)	1012.5 (218.8)	1320.3 (511.8)	1988.3 (666.7)	25.3 (2.4)	26.1 (4.7)
AC - F (N=8)	1800.0 (1581.3)	2046.9 (1607.4)	2601.6 (1563.4)	26.5 (7.8)	27.8 (7.2)
NC - M (N=8)	0.0 (0.0)	1238.3 (340.7)	1668.0 (753.5)	22.8 (3.2)	17.6 (3.6)
NC - F (N=8)	0.0 (0.0)	1175.8 (289.3)	1378.9 (335.9)	22.1 (3.4)	22.9 (7.7)

* WC = High Consumers of Non-Sweet/Low Energy Beverages, AC = Consumers of Artificially-Sweetened Beverages, NC = Consumers of Naturally-Sweetened Beverages; M = Males, F = Females

12.2.3. FOOD DIARIES

All eating behaviours were investigated using specialized food diaries. The diaries were self-report 'portion-size' food diaries, investigating overall quantity consumed, sweetness consumed, quantity of dietary fat consumed, numerous environmental stimuli relevant to appetite and appetite control, and reasons for meal initiation and termination. All variables were measured every time any foods/drinks were consumed - i.e. per eating episode.

12.2.3.1. Quantity Consumed

Overall quantity consumed (weight of food (gram.), total weight consumed (gram.), energy consumed (kcal.) and proportions of all macronutrients consumed (%kcal.)), sweetness consumed (% eating episodes containing sweet foods) and the quantity of dietary fat consumed (as above) were investigated per eating episode by questioning all foods and drinks consumed. All foods and drinks consumed were questioned in as much detail as possible (e.g. cooking methods used), including brand names and details (e.g. 'low calorie'), and the quantity consumed in standard household measures (e.g. teaspoons, cups).

12.2.3.2. Environmental Stimuli

Environmental stimuli relevant to appetite control were investigated per eating episode, by questioning the <u>classification</u> of the eating episode as a meal or snack, the <u>type</u> of meal (if a meal, e.g. breakfast), the <u>relation</u> of all other individuals in the same location at the time of eating, the <u>number</u> of all other individuals in the same location at the time of eating, the <u>location</u> of the eating episode, the <u>time</u> of the start of the eating experience and the <u>duration</u> of the eating episode. All these factors have previously been reported as influential in <u>appetite control</u> (see de Castro, 1997b).

All factors have also previously been reported as influential in <u>appetite</u> (see de Castro, 1997b). Due to possible effects on appetite, all environmental stimuli and physical activity levels were also considered in analysis of quantity consumed. Physical activity was measured per eating episode, by questioning average activity level since the last occasion on which anything was consumed. Physical activity was rated on a standard validated nine-point scale (Bouchard, Tremblay, Leblanc, Lortie, Savard, and Theriault, 1983).

12.2.3.3. Meal Initiation and Termination

Reasons for meal initiation and termination were investigated per eating episode by questioning reasons for starting consuming and for stopping consuming. All response choices were provided, and as many responses could be chosen for each episode as each

participant wished. The responses provided for starting eating were:
Internal - biological - 'empty stomach', 'hunger', 'thirst', 'tired', 'weak'; cognitive - 'influenced', 'medicinal', 'opportunity', 'preparation', 'reward'; emotional - 'boredom', 'negative emotion', 'positive emotion'; food-specific - 'content', 'mouthfeel', 'taste'. External - situational - 'break', 'exposure', 'habit', 'location', 'situation', 'time'; social - 'provided', 'social', 'with others consuming'.

The responses provided for stopping eating were:
Internal - biological - 'full', 'nauseous', 'reduced / satisfied / oversatisfied bodily needs', 'reduced / satisfied / oversatisfied sensational needs'; cognitive - 'all I allow myself', 'potentially satisfied'; emotional - 'reduced emotional state'; food-specific - 'food item spoilt'. External - situational - 'food item finished', 'habit', 'situation', 'time'; social - 'everyone else had finished', 'social'.

An open-ended 'other' option was also provided for both starting and stopping eating. All reasons for starting and stopping eating were taken from the relevant literature (Zylan, 1996; Mook and Votaw, 1992), or were generated from open-ended pilot questionnaires, questioning all reasons for starting and stopping eating over a 24hr period.

All information required per eating episode was questioned on a single page in the diaries, to allow easy completion and reduce effort required. Eighteen eating episode pages were included in each daily diary. Prior to the eating episode pages, six pages of instructions on completion of the food diary, and an example of a completed food diary entry, were given.

The complete food diaries were pocket-sized (21cm x 7.5cm x 21 pages). Piloting was conducted prior to the use of the food diaries in the study, to ensure ease of use and completion. An example of a complete diary is displayed in Appendix 12.1.

12.2.4. PROCEDURE

All diaries were completed for a period of four days, Sunday - Wednesday inclusive, excluding bank holidays. A four day data collection period was used to minimize the amount of recording required per participant, yet still allowed sufficient data collection (de Castro, 1994a; Bingham, 1987). Sunday - Wednesday were specified to minimize differences between participants and to allow consideration of weekend as well as week days (see Bingham, 1987). Prior to completion of the four day data collection period, all participants were also required, to complete a number of additional measures to minimize under-reporting in the data collection period, and to highlight any under-reporting that did occur.

12.2.4.1. Under-reporting

To minimize under-reporting, all participants were trained in the completion of food diaries, prior to the four day data collection period. Training included detailed explanation of the food diary and how it should be completed. Each participant was then also given a practice diary to complete for one day (identical to the actual diaries), and following completion, this was thoroughly checked, any problems were highlighted and rectified, and any questions answered. The practice diary also served to demonstrate to the participant, the time and effort required to complete the diaries. Also to minimize under-reporting, all participants were offered a dietary feedback sheet in return for the completed diaries (see de Castro, 1994a). The dietary feedback sheet included a detailed description of the participants diet, a comparison of their diet with recommended Dietary Reference Values and Reference Nutrient Intakes (Department of Health, 1991), and ways in which their diet could be improved (see MAFF, 1995). The importance of accuracy both for the investigation and for the dietary feedback sheet were repeatedly stressed.

12.2.4.2. Under-reporting Highlighted

To highlight any under-reporting that did occur, all participants were also required to complete an F.F.Q. and a 24hr recall, prior to the start of the study. The F.F.Q. (Margetts, Cade and Osmond, 1989) was a self-report questionnaire questioning all foods and drinks consumed in the typical diet. The 24hr recall was a recall of all foods consumed in the last 24hrs, and was conducted as an interview, to allow prompting and aid memory recall. All data from each of the four diaries for each participant, was compared with data from the F.F.Q., and the 24hr recall, and also with data from the 1-day practice diary, and with a calculation of energy requirements based on energy expenditure equations. The energy expenditure equations were based on estimations of Basal Metabolic Rate dependent on age and weight (Department of Health, 1991), and included an estimation of physical activity levels per participant based on the self-report activity levels over the four day data collection period. Continual concurrent measurements of physical activity were used for increased accuracy (see Haggarty, McNeill, Abu Manneh, Davidson, Milne, Duncan and Ashton, 1994). Energy requirements were assumed to be equal to energy expenditure over the period of the study. Any participant demonstrating unaccountable variation between all measures was discarded from the study. Absolute under-reporting was also investigated by comparison of average energy intake and B.M.R. (see Goldberg, Black, Jebb, Cole, Murgatroyd, Coward and Prentice, 1991). All participants reporting an intake too low for that required to maintain simultaneous basal metabolic costs were discarded from the study.

Participants were also asked at the end of the study, whether they considered their diet to have altered significantly over the data collection period. Again, any participant reporting gross alterations to their diet was discarded from the study. The F.F.Q. and 24hr recall sheet are displayed in Appendices 12.2. and 12.3 respectively. The energy expenditure equations used are displayed in Appendix 12.4.

12.2.5. ANALYSIS

Participant Characteristics: Prior to all analysis of the dependent measures in this study - Quantity Consumed, Environmental Stimuli relevant to appetite control, and reasons for Meal Initiation and Termination, all consumer groups were compared in terms of artificially-sweetened beverage consumption, total sweetened beverage consumption, B.M.I. and Dietary Restraint Score. Groups of high and low consumers were designed to differ in terms of artificially-sweetened beverage consumption. Groups of AC and NC consumers were designed to be similar in terms of total sweetened beverage consumption. All groups were designed to be similar in terms of B.M.I. and restraint. If differences were found between consumer groups, or if a significant relationship was found between B.M.I. and/or dietary restraint and average energy intake over the data collection period (kcal.), B.M.I. and/or dietary restraint score were included in all analyses of Quantity Consumed as covariates. All environmental stimuli and physical activity levels were also correlated with energy intake (kcal.) consumed per eating episode. If a significant relationship was found between any environmental stimulus and/or between physical activity levels and energy intake per eating episode (kcal.), the environmental stimulus/stimuli and/or physical activity levels were also included in all analyses of Quantity Consumed as covariates. Covariates were not used in the analyses on Environmental Stimuli relevant to appetite control or on Meal Initiation and Termination, due to the lack of research to date, demonstrating effects of B.M.I., restraint, (environmental stimuli) and physical activity levels in these measures. Participant characteristics were analysed by 1-way ANOVA (6 groups), and Pearson Product Moment Correlations.

Underreporting Checks: All checks against under-reporting were also analysed prior to all main data analyses. The coefficient of variance (CoV) of all data points per participant was compared with a coefficient of variance of 45%. A coefficient of variance of 45% was used due to the natural variation in the day-to-day diet (see Bingham, 1987). Average energy intake was also compared with a calculation of B.M.R. using a criterion value of 1.2 (see Goldberg, Black, Jebb, Cole, Murgatroyd, Coward and Prentice, 1991).

12.2.5.1. Quantity Consumed

All foods and drinks reported in the diary were converted into consumption levels of energy and all macronutrients using Comp-Eat - a computerised version of McCance and Widdowson's The Composition of Foods (Holland, Welch, Unwin, Buss, Paul and Southgate, 1992), supplements to McCance and Widdowson (Chan, Brown, Church and Buss, 1996; Chan, Brown, Lee and Buss, 1995; Chan, Brown, and Buss, 1994; Holland, Brown and Buss, 1993; Holland, Welch and Buss, 1992; Holland, Unwin and Buss, 1992; Holland, Unwin and Buss, 1991; Holland, Unwin and Buss, 1989; Holland, Unwin and Buss, 1988;), and using manufacturer's information for all manufactured products. Food Portion Sizes (MAFF, 1988) was used to convert standard portion sizes into weight. All alcohol consumed was included in addition to all other foods. Alcohol has previously been suggested to have an additive effect on energy intake (e.g. Tremblay, Wouters, Wenker, St. Pierre, Bouchard and Depres, 1995). Alcohol consumption is not investigated separately.

Overall quantity consumed (weight of food (gram.), total weight consumed (gram.), energy content (kcal.) and proportions of all macronutrients consumed (%kcal.)), sweetness consumed (% eating episodes containing sweet foods) and quantity of dietary fat consumed (as above) were averaged over the four day data collection period and were analysed by 2-way ANCOVA (gender by consumer, covariates - Dietary Restraint Score, all environmental stimuli). Male and female participants were also analysed separately using 1-way ANCOVA (consumer, covariates - Dietary Restraint Score, all environmental stimuli). (Sweetness consumed was measured as % eating episodes containing sweet food items, due to the dissociation between sweetness and energy consumed when consuming artificial sweeteners and artificially-sweetened products, the dissociation between sweetness and weight consumed when consuming sweetness in both solid and liquid forms, and the reporting of individual food items as opposed to composite foods in the diaries).

12.2.5.2. Environmental Stimuli

Environmental stimuli relevant to appetite control (meal classification, meal type, relation of all individuals present, number of all individuals present, location, meal start time, meal duration) were analysed by correlation. For all environmental stimuli, environmental stimulus per eating episode was correlated with energy intake per eating episode, for all eating episodes, for all participants in each consumer group. Group correlation coefficients were then compared using Fisher's (1921) equations (see Howell, 1997). For all categorical environmental stimuli, e.g. location of eating episode, all categories were scored prior to correlation. All scoring was based on previously reported influences on appetite (see de Castro, 1997a; de Castro, 1997b; de Castro, 1994b):- meal classification was ordered by size (snack = 1, meal = 2); meal types were ordered by time (breakfast = 1, brunch = 2, lunch = 3, tea/dinner = 4, supper = 5); relations were ordered by strength of the relationship (stranger = 1, colleague = 2, housemate = 3, friend = 4, family = 5, partner = 6); and location was ordered by impact on consumption as previously reported (street = 1, work = 2, non-eating (non-work) establishment = 3, home = 4, eating/drinking establishment = 5). Due to the restrictions in Fisher's (1921) equations allowing comparison only of two correlation coefficients at a time, differences between consumer groups were specified prior to analysis (WC and AC, NC and AC, WC and NC) and differences between genders were not investigated

12.2.5.3. Meal Initiation and Termination

Reasons for meal initiation (Internal - biological, cognitive, emotional, food-specific, and External - situational, social) and meal termination (Internal - biological, cognitive, emotional, food-specific, and External - situational, social) were analysed by calculating the proportion of all eating episodes initiated or terminated for each reason, for each participant. The percentage of meals initiated and meals terminated were then analysed by 2-way ANOVA (gender by consumer). Male and female participants were also analysed separately using 1-way ANOVA (consumer).

All missing data were recognised as missing by the computer. None were replaced.

12.3. RESULTS

Note: WC consumers = low consumers of artificially-sweetened beverages, high consumers of non-sweetened beverages; AC = high consumers of artificially-sweetened beverages; NC consumers = low consumers of artificially-sweetened beverages, high consumers of naturally-sweetened beverages.

12.3.1. PARTICIPANT CHARACTERISTICS

12.3.1.1. Artificially-Sweetened Beverage Consumption

Groups of high (AC) and low (WC, NC) consumers were designed to differ in artificially-sweetened beverage consumption. Significant differences were found ($F(5,47)=11.00$, $p<0.001$). Male AC consumers consumed more artificially-sweetened beverages than male and female WC and NC consumers (all: $t(14)=12.95$, $p<0.001$). Female AC consumers consumed more artificially-sweetened beverages than male and female WC and NC consumers (all: $t(14)=3.21$, $p<0.001$). No significant differences were found between male and female AC consumers ($t(14)=-1.39$, $p=0.19$), or between male and female WC and NC consumers.

12.3.1.2. Total Sweetened Beverage Consumption

High consumers of artificially-sweetened beverages (AC) and high consumers of naturally-sweetened beverages (NC) were also designed not to differ in total sweetened beverage consumption. No significant differences were found ($F(5,47)=1.73$, $p=0.18$).

12.3.1.3. B.M.I.

Groups of consumers were designed to be similar in B.M.I. No significant differences were found between consumer groups in B.M.I. ($F(5,47)=1.87$, $p=0.12$). No correlation was also found between B.M.I. and average energy intake over the data collection period (kcal.) in all participants ($r=-0.082$, $p=0.58$), in male participants ($r=0.332$, $p=0.11$) or in female participants ($r=0.092$, $p=0.67$). B.M.I. was not used as a covariate in any analyses.

12.3.1.4. Dietary Restraint

Groups of consumers were designed to be similar in Dietary Restraint. Significant differences however were found ($F(5,47)=6.90$, $p<0.001$). Male WC consumers were significantly less restrained than male AC and NC consumers and female WC, AC and NC consumers (smallest $t(14)=-2.96$, $p=0.01$). Male NC consumers were significantly less restrained than male AC consumers ($t(14)=4.07$, $p=0.001$) and female AC consumers ($t(14)=3.57$, $p=0.003$). No significant differences were found between the four more highly restrained groups (male AC, female WC, AC, NC) (largest $t(14)=1.75$, $p=0.10$). Significant correlations were also found between dietary restraint score and average energy intake over the data collection period (kcal.) (all participants: $r=-0.468$, $p=0.001$; male participants: $r=-0.385$ $p=0.06$ (marginally significant); female participants: $r=-0.428$, $p=0.04$).

Due to the differences found between groups, the significant relationships and the potential influence of dietary restraint on the measures taken in this study, D.E.B.Q.-R. score was used as a covariate in all analyses of Quantity Consumed, on all participants, male participants and female participants. The significance of the covariate in all analyses in which it was used, are shown following all ANCOVA analyses in Appendix 12.6.

12.3.1.5. Environmental Stimuli

Significant correlations were found between all Environmental Stimuli and energy intake per eating experience (kcal.) in analysing all participants - classification as a meal or snack ($r=0.669$, $p<0.001$), type of meal ($r=0.493$, $p<0.001$), relation of all other individuals present ($r=0.204$, $p<0.001$), number of all other individuals present ($r=0.092$, $p=0.001$), location ($r=0.118$, $p<0.001$), meal start time ($r=0.113$, $p<0.001$) and meal duration

($r=0.167$, $p<0.001$). Significant correlations were also found between all Environmental Stimuli measured and energy intake per eating experience (kcal.) in analysing all male participants only (smallest $r=0.077$, $p=0.03$) and all female participants only (smallest $r=0.138$, $p<0.001$). All environmental stimuli were included as covariates in all analyses on Quantity Consumed. The significance of all covariates in all analyses in which they were used, are shown following all ANCOVA analyses in Appendix 12.6.

12.3.1.6. Physical Activity Levels

No significant correlation was found between Physical Activity Levels and Energy Intake per eating experience (kcal.) (all participants: $r=0.039$, $p=0.113$; male participants: $r=0.016$, $p=0.70$; female participants: $r=0.069$, $p=0.11$). No significant correlation was also found between average Physical Activity Levels and Average Energy Intake over the data collection period (kcal.) (all participants: $r=0.132$, $p=0.37$; male participants: $r=0.231$, $p=0.28$; female participants: $r=-0.089$, $p=0.69$). No significant differences were also found between consumer groups in average physical activity levels ($F(5,47)=1.59$, $p=0.18$). Physical activity levels were not included as covariates in any analyses.

12.3.2. UNDER-REPORTING CHECKS

Coefficients of variance were less than 45% for 45 (out of 48) participants. For three participants, coefficients of variance obtained were 46%, 48% and 59%. On closer inspection, two of these values (46%, 48%) were a result of overestimations in energy expenditure calculations. These however, were considered to be more likely to be a result of a general overestimation of physical activity levels by the participant, as opposed to an underestimation of food intake. The third value (59%) was found to be a result of an enormous intake of alcohol on one of the days in the data collection period. This is more likely to be an accurate reporting of increased intake on one day than an indication of inaccurate under-reporting on all other days. No participants was found to report a Energy Intake : B.M.R. ratio of less than 1.2. None of the participants were considered to be grossly under-reporting in this study. All participants were included in all analyses.

12.3.3. QUANTITY CONSUMED

12.3.3.1. All Participants

Quantity Consumed: No significant differences were found between genders in all measures of intake - weight of food consumed (gram.), total weight consumed (gram.), energy consumed (kcal.), and proportions of all macronutrients consumed (%kcal.) (largest

F(1,47)=2.99, p=0.09). Significant differences were found between consumers in measures of proportions of energy consumed from protein (F(2,47)=28.65, p=0.01). AC consumers consumed more energy from protein than WC (t(30)=-2.13, p=0.04) and NC consumers (t(30)=3.09, p=0.04). No differences were found between WC and NC consumers (t(30)=1.58, p=0.12). No significant differences were found between consumers in any other measures of intake (largest F(2,47)=1.68, p=0.20). No significant interactions were found (largest F(2,47)=1.49, p=0.24). Trends however can be seen, in weight of food consumed, total weight consumed and energy consumed. In male participants, in weight of food consumed and total weight consumed, no differences can be seen between consumers. In female participants, AC consumers reported consuming more weight of food and more total fluid than WC and NC consumers. In energy consumed, in male and female participants, AC consumers reported consuming less than WC and NC consumers. Quantity consumed - weight of food consumed (gram.), total weight consumed (gram.) and energy consumed (kcal.) averaged over four days are displayed in Figures 12.1 - 12.3. Quantity Consumed (all measures) is also shown (with analysis) in Appendix 12.5.

Sweetness Consumed: In percentage of eating episodes containing sweet foods, no significant differences were found between genders (F(1,47)=1.74, p=0.20). Significant differences were found between consumers (F(2,47)=28.65, p<0.001). WC consumers consumed a significantly lower frequency of sweetness than AC (t(30)=-5.92, p<0.001) and NC consumers (t(30)=-6.62, p<0.001). No differences were found between AC and NC consumers (t(30)=0.22, p=0.83). No interaction was found F(2,47)=1.15, p=0.33). Of additional interest, in AC consumers, 31.4% of all eating episodes containing sweetness also contained no energy (i.e. artificially-sweetened beverages or artificially-sweetened gum consumed alone). Sweetness Consumed (% eating episodes containing sweet foods) are displayed in Figure 12.4. and is shown (with analysis) in Appendix 12.5.

Figure 12.1: Weight of Food Consumed (gram.) mean (st.dev.) per Day - All Participants

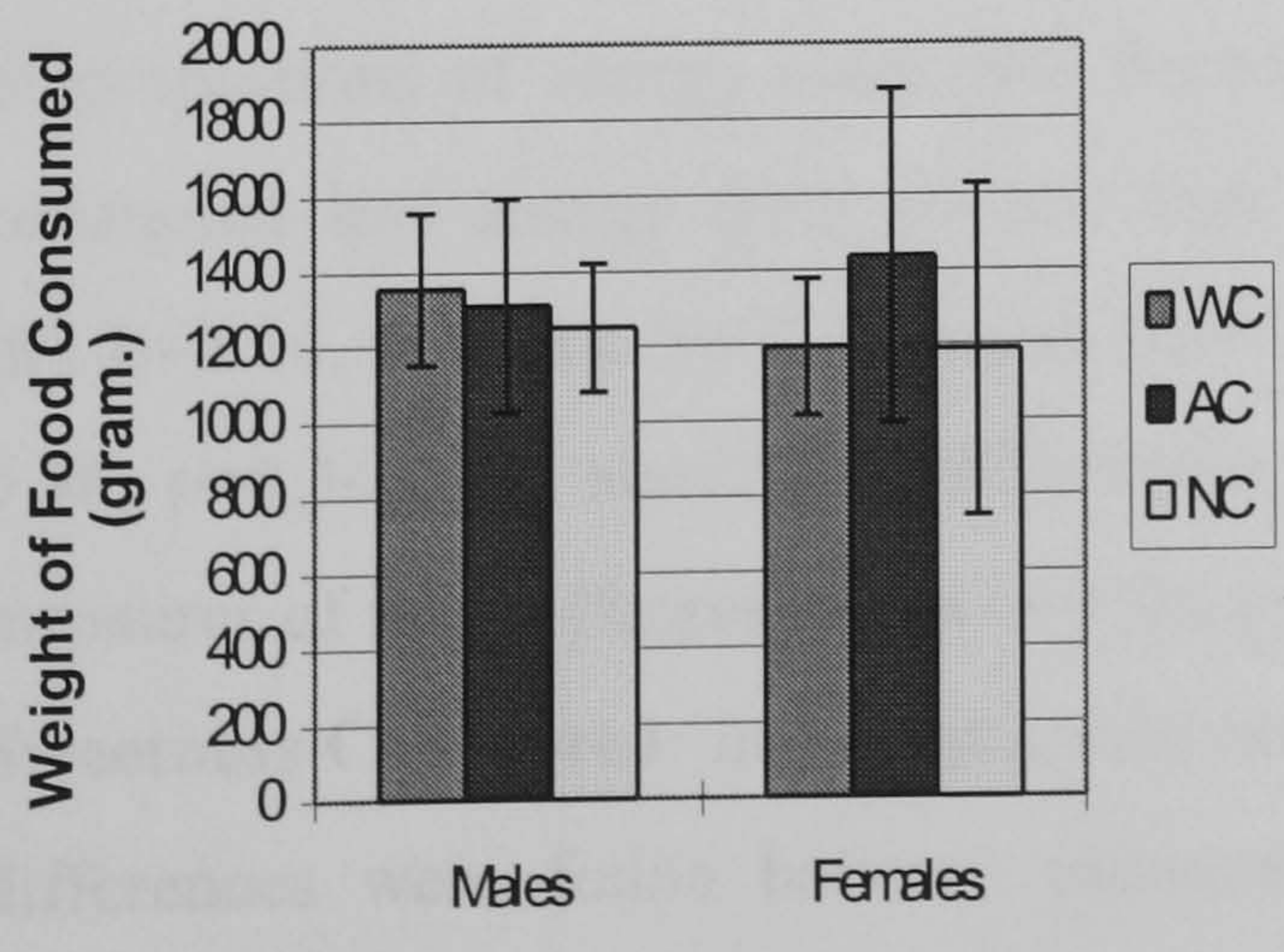


Figure 12.2: Total Weight Consumed (gram.) mean (st.dev.) per Day - All Participants

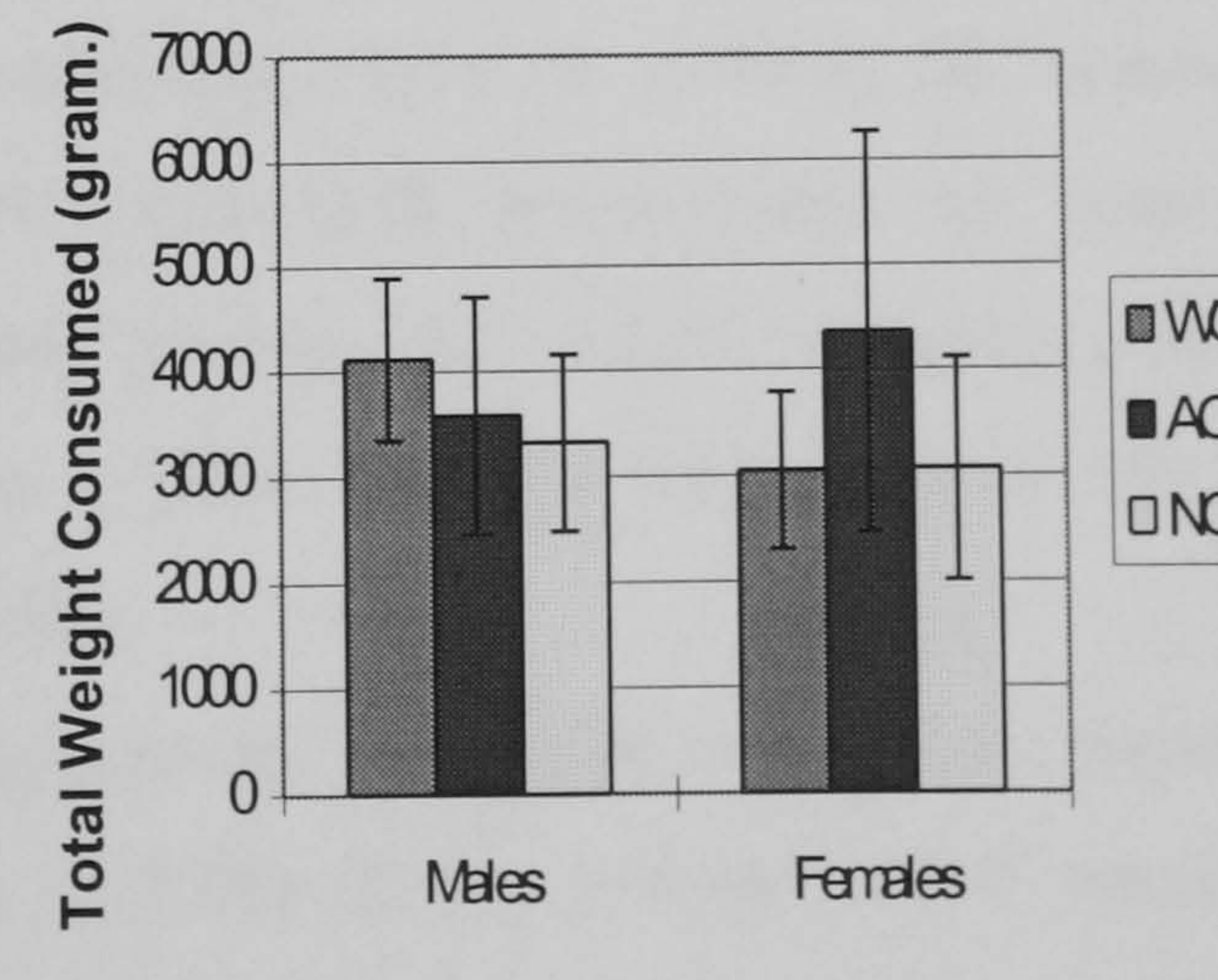


Figure 12.3: Energy Consumed (kcal.) mean (st. dev.) per Day - All Participants

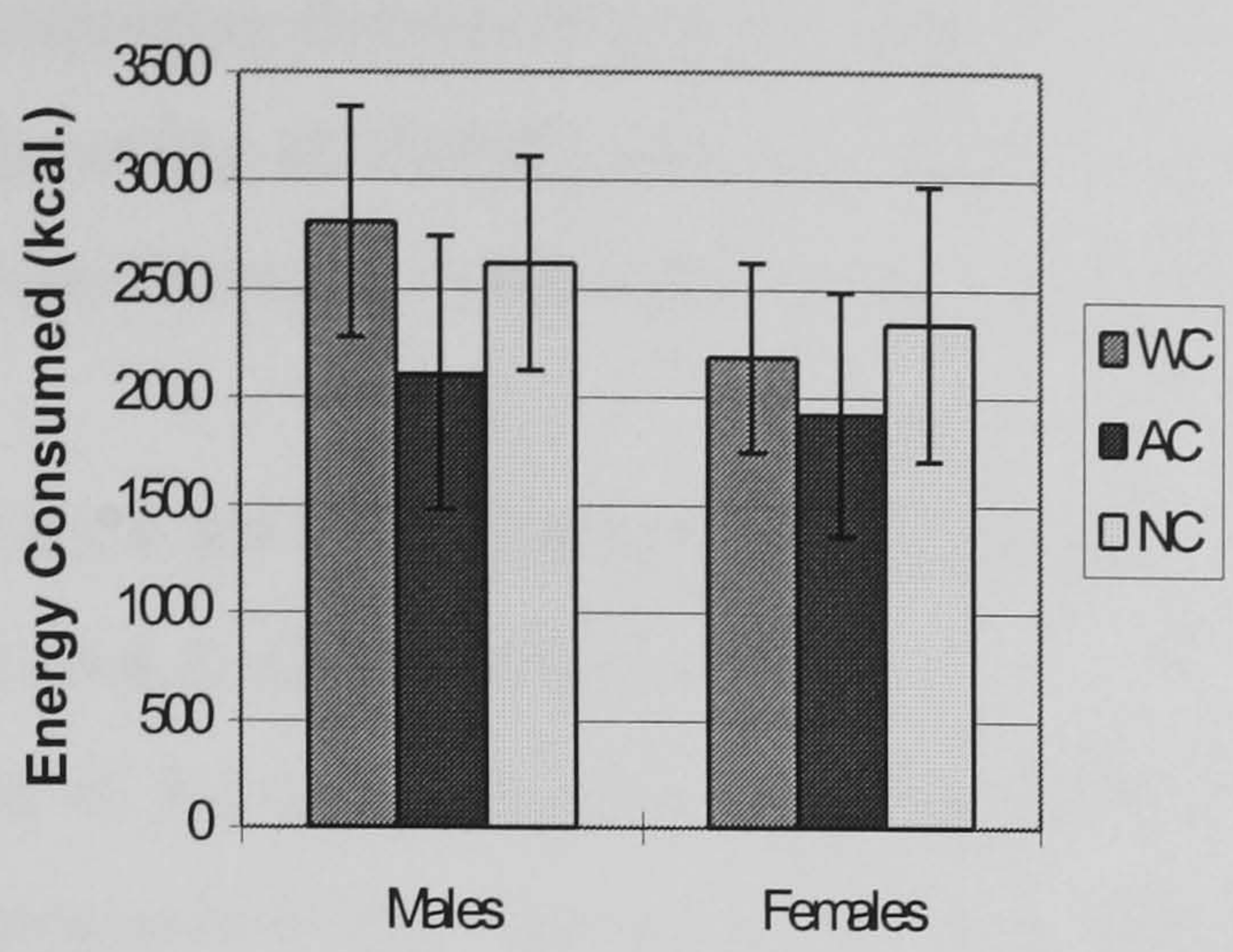
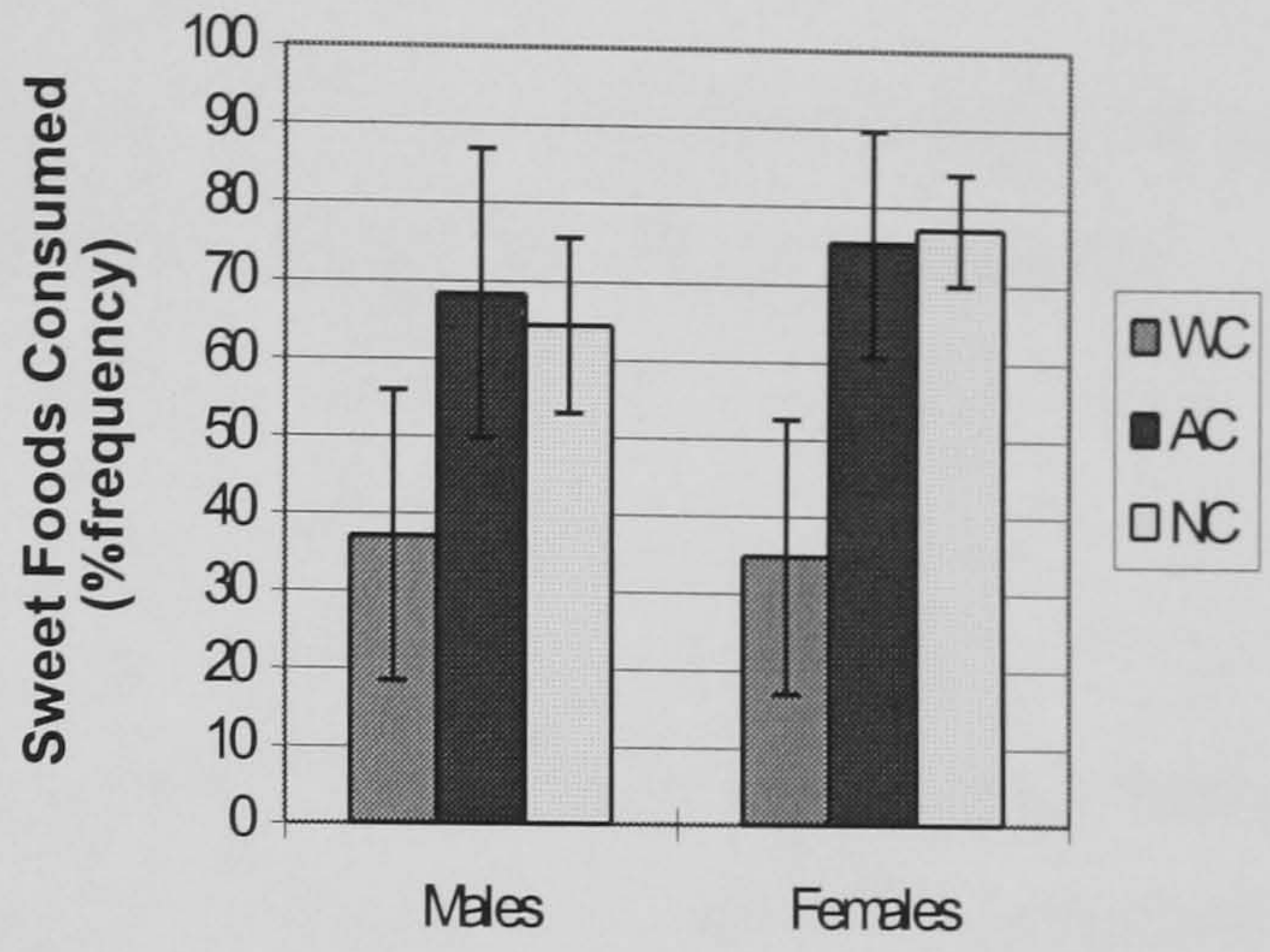


Figure 12.4: Sweetness Consumed (%frequency) mean (st. dev.) per Day - All Participants



Quantity of Dietary Fat Consumed: As reported above, no significant differences were found in quantity of dietary fat consumed between genders ($F(1,47)=0.71$, $p=0.79$) or consumers ($F(1,47)=0.25$, $p=0.78$). No interaction was found ($F(2,47)=0.73$, $p=0.49$).

12.3.3.2. Male Participants

Quantity Consumed: No significant differences were found between consumers in all measures of intake (largest $F(2,23)=2.35$, $p=0.14$).

Sweetness Consumed: No significant differences were found between consumers in the percentage of eating episodes containing sweet foods ($F(2,23)=3.05$, $p=0.08$). Trends were seen however: WC consumers consumed a lower frequency of sweet food items than AC and NC consumers, and no differences were found between AC and NC consumers. In AC consumers, 21.8% of all eating episodes containing sweetness also contained no energy.

Quantity of Dietary Fat Consumed: As reported above, no significant differences were found between consumers in quantity of dietary fat consumed ($F(2,23)=2.35$, $p=0.14$).

12.3.3.3. Female Participants

Quantity Consumed: Significant differences were found between consumers in measures of proportions of energy consumed from protein ($F(2,23)=4.18$, $p=0.04$). NC consumers consumed less energy from protein than WC ($t(14)=2.86$, $p=0.01$) and AC consumers ($t(14)=3.34$, $p=0.01$). No differences were found between WC and AC consumers ($t(14)=-0.98$, $p=0.34$). No significant differences were found between consumers in any other measures of intake (largest $F(2,47)=3.08$, $p=0.08$).

Sweetness Consumed: In percentage of eating episodes containing sweet foods, significant differences were found between consumers ($F(2,23)=22.60$, $p<0.001$). WC consumers consumed a significantly lower frequency of sweetness than AC ($t(14)=-4.99$, $p<0.001$) and

NC consumers (t(14)=-6.23, p<0.001). No differences were found between AC and NC consumers (t(14)=-0.32, p=0.76). In AC consumers, 41.0% of all eating episodes containing sweetness also contained no energy.

Quantity of Dietary Fat Consumed: As reported above, no significant differences were found between consumers in quantity of dietary fat consumed (F(2,23)=1.15, p=0.35).

12.3.4. ENVIRONMENTAL STIMULI

12.3.4.1. All Participants

In all participants, significant differences were found between WC and AC consumers in measures of the relation of all other individuals present (Z=-2.05, p=0.04), number of all other individuals present (Z=2.78, p=0.006), and meal duration (Z=4.12, p<0.001). A lower correlation was found between energy intake and the relation of all other individuals present in WC consumers than in AC consumers. A higher correlation was found between energy intake and number of all individuals present and meal duration in WC consumers than in AC consumers. No differences were found in any of the other measures (largest Z=1.19, p=0.23). Significant differences were found between NC and AC consumer groups in measures of classification (Z=2.28, p=0.02), relation of all other individuals present (Z=2.10, p=0.03), location (Z=-2.03, p=0.04), and meal duration (Z=-2.69, p=0.01). A lower correlation was found between energy intake and eating experience classification and relation of all other individuals present in NC consumers than in AC consumers. A higher correlation was found between energy intake and location and meal duration in NC consumers than in AC consumers. No differences were found in any of the other measures (largest Z=-1.24, p=0.21). No significant differences were found between WC and NC consumers (largest Z=1.56, p=0.12). All correlation coefficients for all correlations between Energy Intake and all Environmental Stimuli per Eating Episode, for All Participants, are displayed below in Table 12.2.

Table 12.2: Correlation Coefficients for all Correlations between Energy Intake and all Environmental Stimuli per Eating Episode, for All Participants, in Study 8.

Measure	WC Consumers			AC Consumers			NC Consumers		
	CC *	N	p	CC	N	p	CC	N	p
Classification	0.679	558	<0.001	0.709	575	<0.001[b]	0.637	501	<0.001[b]
Meal Type	0.526	173	<0.001	0.534	168	<0.001	0.456	168	<0.001
Relation	0.171	557	<0.001[a]	0.288	558	<0.001[ab]	0.165	498	<0.001[b]
Number	0.205	484	<0.001[a]	0.025	489	0.58[a]	0.104	484	0.02
Location	0.121	558	0.004	0.067	575	0.11[b]	0.189	501	<0.001[b]
Start Time	0.149	555	<0.001	0.079	562	0.06	0.100	489	0.02
Duration	0.292	529	<0.001[a]	0.048	536	0.27[ab]	0.216	464	<0.001[b]

* CC = Pearson product moment Correlation Coefficient, N = Sample Size, p = significance

[a b] denote significant differences between consumers

12.3.4.2. Male Participants

In male participants, significant differences were found between WC and AC consumers in measures of number of all other individuals present (Z=3.12, p=0.001), location (Z=1.99, p=0.05), and meal start time (Z=2.40, p=0.02). A higher correlation was found between energy intake and number of all individuals present, location and meal start time in WC consumers than in AC consumers. Significant differences were found between NC and AC consumers in measures of relation of all other individuals present (Z=2.08, p=0.04), and location (Z=-2.50, p=0.01). A lower correlation was found between energy intake and relation of all other individuals present in NC consumers than in AC consumers. A higher correlation was found between energy intake and location in NC consumers than in AC consumers. No significant differences were found between WC and NC consumer groups (largest Z=1.93, p=0.06). All correlation coefficients are shown in Appendix 12.7.

12.3.4.3. Female Participants

In female participants, significant differences were found between WC and AC consumers in measures of meal duration (Z=6.01, p<0.001). A higher correlation was found between energy intake and meal duration in WC consumers than in AC consumers. Significant differences were found between NC and AC consumers in measures of meal classification (Z=3.27, p=0.001) and meal duration (Z=-4.05, p<0.001). A lower correlation was found between energy intake and eating experience classification in NC consumers than in AC consumers. A higher correlation was found between energy intake and meal duration in NC consumers than in AC consumers. No significant differences were found between WC and NC consumer groups (largest Z=1.94, p=0.06). All correlation coefficients are shown in Appendix 12.8.

12.3.5. MEAL INITIATION AND TERMINATION

12.3.5.1. All Participants

Meal Initiation: In all participants, no significant differences were found between genders or consumers in the proportion of eating episodes initiated for internal reasons (gender: largest F(1,47)=1.21, p=0.28; consumer: largest F(2,47)=1.21, p=0.31) or external reasons (gender: largest F(1,47)=0.83, p=0.37; consumer: largest F(2,47)=0.16, p=0.85). No interactions were found (largest F(2,47)=3.01, p=0.06). Proportion of Eating Episodes Initiated for All Reasons (%frequency) are shown in Appendix 12.9.

Meal Termination: No significant differences were found between genders in the proportion of eating episodes terminated for internal reasons (largest F(1,47)=2.65, p=0.11) or external reasons (largest $F(1,47)=0.26$, $p=0.62$). Significant differences were found between consumers in the proportion of eating episodes terminated for social reasons ($F(2,47)=3.87$, $p=0.03$). WC consumers reported a higher proportion of eating episodes terminated for social reasons than AC ($t(30)=2.33$, $p=0.03$) and NC consumers ($t(30)=2.09$, $p=0.05$). No differences were found between AC and NC consumers ($t(30)=-0.26$, $p=0.80$). No differences were found in the proportion of eating episodes terminated for internal reasons (largest $F(2,47)=0.77$, $p=0.47$) and no other differences were found in the proportion of eating episodes terminated for external reasons ($F(2,47)=0.83$, $p=0.45$). No interactions were found (largest $F(2,47)=0.04$, $p=0.96$). Proportion of Eating Episodes Terminated for All Reasons (%frequency) are shown in Appendix 12.10.

12.3.5.2. Male Participants

Meal Initiation: In male participants, no significant differences were found between consumers in the proportion of eating episodes initiated for internal reasons (largest $F(2,23)=2.52$, $p=0.11$) or external reasons (largest $F(2,23)=1.77$, $p=0.20$).

Meal Termination: Significant differences were found between consumers in the proportion of eating episodes terminated for social reasons ($F(2,23)=8.72$, $p=0.002$). WC consumers reported a higher proportion of eating episodes terminated for social reasons than AC ($t(14)=3.00$, $p=0.01$) and NC consumers ($t(14)=3.17$, $p=0.01$). No differences were found between AC and NC consumers ($t(14)=0.21$, $p=0.84$). No differences were found in the proportion of eating episodes terminated for internal reasons (largest $F(2,23)=1.37$, $p=0.28$) and no other differences were found in the proportion of eating episodes terminated for external reasons ($F(2,23)=0.83$, $p=0.45$).

12.3.5.3 Female Participants

Meal Initiation: In female participants, no significant differences were found between consumers in the proportion of eating episodes initiated for internal reasons (largest $F(2,23)=1.22$, $p=0.31$) or external reasons (largest $F(2,23)=1.39$, $p=0.27$).

Meal Termination: No significant differences were found in the proportion of eating episodes terminated for internal reasons (largest $F(2,23)=2.27$, $p=0.13$) or external reasons (largest $F(2,23)=0.64$, $p=0.54$).

12.4. DISCUSSION

Note: Before the results of this study are discussed, it should be noted that this study is very small for a field study. Field studies are recommended to be of at least 100 participants per participant group in order to detect a 10-16% variation between groups, due to the amount of variation and number of variables influential in appetite and appetite control in the natural world (Bingham, 1987). Consequently, due to the lack of power in this study, few significant effects were found and some important effects may have been incorrectly classified as non-significant. Trends are reported as well as significant effects.

The results of this study also should be considered with extreme caution. Due to the very small number of participants who took part in the study and the very small amount of time for which data was collected, all effects found may be specific to this participant sample or this data collection period. The findings of this study may also be highly influenced by the method of data collection - self-report food diary completion. Attempts were made throughout the study, to minimize any potential effects of the collection of data by self-report diaries. Whilst no participants were considered to be grossly under-reporting however, many participants did consider their eating patterns to have been influenced by the necessary completion of the diaries - most notably - small frequent eating episodes tended to be replaced by larger less frequent eating episodes. Similar effects of diary completion have been previously reported (e.g. MacDiarmid, PhD thesis, 1997). Small effects of under-reporting are highly likely in this study. These effects however are considered to be only small, and non-systematic (non-consumer specific) (Bingham, 1987). Problems may be encountered however, as a result of a possible selective under-reporting by consumers of a higher B.M.I. and a possible selective under-reporting of high-fat foods (see Chapter 5, section 5.4.2.1). Attempts were made to counteract these problems, but the possibility of effects should be borne in mind throughout interpretation of all findings.

In analysing all participants, associations were found in this study, between the high consumption of artificially-sweetened beverages and various specific eating behaviours. Related to appetite, associations were found mainly as trends. These trends differed between male and female participants, and were more marked in female than in male participants. Related to appetite control, associations were found in all participants, in male participants and in female participants, and were similar in all participant groups, but were more marked in male participants than in female participants.

12.4.1. EFFECTS IN APPETITE - FEMALE PARTICIPANTS

Investigating appetite, in female participants, the main findings of this study are:

- High consumers consumed more weight of food and more total weight than low consumers (trend only).
- High consumers consumed less energy than low consumers (trend only).
- High consumers consumed a similar frequency of sweetness as low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC), but consumed a greater frequency of sweetness than low consumers of artificially-sweetened beverages but high consumers of non-sweetened beverages (WC).
- High consumers consumed a similar proportion of energy from fat as low consumers.

In measures of overall appetite, differences were found between female high and low consumers of artificially-sweetened beverages, though did not reach significance. High consumers of artificially-sweetened beverages consumed more weight of food and more total weight than low consumers. High consumers also consumed less energy than low consumers. The consumption of high levels of weight of food and low levels of energy is a clear demonstration of the high consumption of foods of low energy density. Support for an association between the high consumption of artificially-sweetened beverages and the high consumption of foods of low energy density (artificial sweeteners, artificially sweetened products, fruit, vegetables) is found on closer inspection of the data in this study, and has also been found previously in this thesis (Study 2), and in the relevant published literature (e.g. Schoeller, Shay and Kushner, 1997; Alexander and Tepper, 1995; Newsome, 1993). The high consumption of foods of low energy density has previously been suggested, as a means of appetite control (Alexander and Tepper, 1995; Tepper, 1992; Laessle, Tuschl, Kotthaus and Pirke, 1989). High consumers of artificially-sweetened beverages here thus, may be considered to be demonstrating an increased deliberate control of appetite.

Interesting trends were also found in this study, in considering weight of food consumed, energy consumed and total weight consumed (food and fluid). Comparing weight of food consumed and total weight consumed, female high consumers of artificially-sweetened beverages reported consuming a greater difference between total weight consumed and weight of food consumed than low consumers - i.e. female high consumers of artificially-sweetened beverages reported a greater consumption of fluids. This greater fluid consumption in the high consumers remains currently unexplained, but high fluid consumption levels in the high consumers can also be inferred from other studies in this thesis (Studies 3, 4, and 5). Comparing energy consumed and total weight consumed, female high consumers of artificially-sweetened beverages also reported a greater difference between energy consumed and total weight consumed than low consumers. This again can be considered to be indicative of the high consumption of food items of low energy density, particularly low energy fluids - water and artificially-sweetened beverages (Alexander and Tepper, 1995). The consideration of fluids as food items of low energy density may also explain the high consumption of fluids in high consumers.

Significant differences were found in this study in consumption of sweetness. Female high consumers of sweetened beverages (both high consumers of artificially-sweetened beverages and high consumers of naturally-sweetened beverages) reported a higher consumption of sweetness than low consumers. This finding is unsurprising. High consumers of artificially-sweetened beverages and naturally-sweetened beverages are self-selecting to consume high levels of sweetened beverages. An increased consumption and preference for all sweetened foods would be expected in these consumers (Laeng, Berridge and Butter, 1993; Pliner, Pelchat and Grabski, 1993; Conner and Booth, 1988; Pliner, 1982). An increased consumption and preference for all sweetened foods has been previously reported in high consumers of sweetened beverages (e.g. Addington, PhD Thesis, 1988; Kanders, Lavin, Kowalchuk, Greenberg and Blackburn, 1988). Not all previous studies however have found an association between the high consumption of sweetened beverages and increased preference for sweetness (e.g. Blackburn, Kanders, Lavin, Keller and Whately, 1997). The results above also do not support those found previously in this thesis in Study 6. In Study 6, no differences were found between high consumers of artificially-sweetened beverages, high consumers of naturally-sweetened beverages and high consumers of non-sweetened beverages in preferences for sweetness. The discrepancy between study findings however can be attributed to the differing methodologies used. Study 6 investigated preferences for sweetness in the unnatural sampling of unflavoured milkshake solutions. This study investigated the natural frequency of the consumption of all sweetened food items within the natural world. The greatly increased ecological validity of this study, and the pattern and significance of the results found suggest that self-selecting high and low consumers of sweetened beverages do differ in consumption levels of sweetness and are very likely to differ in preferences for sweetness.

In measures of consumption of dietary fat, in this study, no differences were found between female high and low consumers of artificially-sweetened beverages. No differences between consumers in consumption of dietary fat were also found in other studies in this thesis (Studies 3, 4, and 5), and no preferences for fat were found when specifically investigated in Study 6. No differences between consumers in consumption levels of dietary fat have also been reported previously in association with the repeated consumption of artificial sweeteners (e.g. Blackburn, Kanders, Lavin, Keller and Whately, 1997; Gatenby, Aaron, Jack and Mela, 1997; Lavin, French and Read, 1997). An absence of differences between consumers in the consumption of dietary fat has previously been explained as a result of a very strict control of fat intake in certain consumers (Lavin, French and Read, 1997, and see de Castro, 1995). It is possible that fat consumption is highly controlled in the high consumers of artificially-sweetened beverages in this study. In terms of appetite, the similar levels of energy consumed from dietary fat in all consumers, demonstrate no differences between consumers. In terms of appetite control, the similar levels of energy consumed from fat may demonstrate an increase in the cognitive control of appetite in high consumers of artificially-sweetened beverages compared to the low consumers. Unfortunately however, the lack of differences in fat consumption between consumers in this study may also be a result of the methodology used. Under-reporting is a problem in all food diary studies, but the problem is further compounded by the increased likelihood of under-reporting both of foods perceived to be unhealthy (typically high-fat foods) and by individuals of a higher B.M.I. (see Chapter 5, section 5.4.2.1). Apparent similar levels of fat intake in high and low consumers may be a result of the increased underreporting of high- fat foods by the high consumers. The likelihood of this increased under-reporting however can not be checked or estimated from the data in this study.

12.4.2. EFFECTS IN APPETITE - MALE PARTICIPANTS

Investigating appetite in male participants, the main findings of this study are:

• High consumers consumed a similar weight of food and a similar total weight as low consumers.

• High consumers consumed less energy than low consumers (trend only).

• High consumers consumed a similar frequency of sweetness as low consumers of artificially-sweetened beverages but high consumers of naturally-sweetened beverages (NC), but consumed a greater frequency of sweetness than low consumers of artificially-sweetened beverages but high consumers of non-sweetened beverages (WC) (trend only).

• High consumers consumed a similar proportion of energy from fat as low consumers.

In measures of overall appetite in male participants, no differences were found between high and low consumers of artificially-sweetened beverages in weight of food consumed or in total weight consumed, although trends were found in energy consumed. High consumers of artificially-sweetened beverages consumed less energy than low consumers. As in the female participants, these effects are probably indicative of the higher consumption of foods of low energy density, in high consumers, and can be explained as a deliberate means of appetite control (Tepper, 1992).

In sweetness consumed, similar results were found in male participants as were found in the female participants, although did not reach significance. High consumers of artificially-sweetened beverages and high consumers of naturally-sweetened beverages reported consuming more sweetness than high consumers of non-sweetened beverages. The increase in consumption of sweetness can be explained as in female participants as a result of preferences and familiarity. The absence of significance however suggests only weak effects in males and much weaker effects than those found in females.

In quantity of dietary fat consumed, no differences were found between high and low consumers of artificially-sweetened beverages. As detailed in the discussion on the findings in female participants, this may be a demonstration of no actual differences, or may be demonstrative of a more strict control of fat intake in the high consumers of artificially-sweetened beverages (Lavin, French and Read, 1997, de Castro, 1995).

12.4.3. EFFECTS IN APPETITE CONTROL - ALL PARTICIPANTS

In investigating appetite control, in all participants, the main findings of this study are:

• High consumers reported a stronger relationship between energy intake and the relation of all other individuals present and the classification of each eating episode, than low consumers.

• High consumers reported a weaker relationship between energy intake and the number of all other individuals present, the location of the eating episode and the duration of the eating episode, than low consumers.

• High consumers and low consumers reported no clear differences in reasons for meal initiation and meal termination.

In measures of appetite control in this study, differences were found between high and low consumers of artificially-sweetened beverages, though only in the measures of non-deliberate appetite control.

In measures of non-deliberate appetite control, high consumers reported a stronger relationship between energy intake and the relation of all other individuals present and the classification of each eating episode, than low consumers, and a weaker relationship between energy intake and the number of all other individuals present, the location of the eating episode and the duration of the eating episode, than low consumers. These differences are very interesting. Appetite in high consumers of artificially-sweetened beverages would appear to be more influenced by the relation of all other individuals present at the time of the eating episode, and the classification of the eating episode as a meal or a snack. Appetite in the low consumers would appear to be more influenced by the number of other individuals present at the time of the eating episode, the location of the eating episode and the duration of the eating episode. Increases in appetite in response to number of other individuals present, location and duration have all previously been suggested to be predominantly a result of increasing the amount of time spent eating (see de Castro, 1997b; Kim and Kissileff, 1996; de Castro, 1994b). In addition to increasing time spent consuming, increases in appetite in response to the relation with all other individuals present however, have also been attributed to a disinhibitory effect of individuals of close relation (friends, family and partners), as a result of increased relaxation (de Castro, 1994b). The difference between high and low consumers of artificially-sweetened beverages found in this study thus, may be indicative of an increased disinhibition and thereby an increased cognitive control of food intake in the high consumers. Further support for the increased use of cognitions in the high consumers can also be inferred from the stronger relationship in these consumers between energy intake and the classification of the eating episode as a meal or a snack. Classification of an eating episode is a purely cognitive appraisal (Gatenby, 1997; Cathro, 1992).

Actual differences aside it also interesting that differences were found only between high consumers of artificially-sweetened beverages and low consumers (WC and NC). No differences were found between WC and NC consumers. All differences found however, may be a result not of actual differences, but of differences in reporting as a result of differing definitions and differing uses of differing terms (e.g. colleagues, housemates and friends). Differences in reporting however are unlikely to be consumer-group-specific.

In measures of deliberate appetite control in this study, no differences were found between high and low consumers of artificially-sweetened beverages. High and low consumers were initiating and terminating eating episodes for similar reasons. These findings are surprising. Differences were found between consumers in measures of non-deliberate appetite control in this study, and were found in self-report measures of appetite control in Study 7. Differences in appetite control between high and low consumers of artificially-sweetened beverages and other artificially-sweetened products have also been previously reported (Schoeller, Shay and Kushner, 1997; Alexander and Tepper, 1995).

The absence of findings in this study may be due to the methodology used. All participants were directly asked for reasons for meal initiation and termination. There is no guarantee however that individuals are actually aware of their reasons for starting and stopping eating or are able to report them (Mook and Votaw, 1992). This direct questioning also, unlike many other measures of appetite control, is very open to influence from perceived experimental demand characteristics, and deliberate and non-deliberate impression management (Coolican, 1990). All responses may simply be a result of a management of impressions to result in the appearance of a normal, healthy individual and lifestyle. In support of the methodology however, one difference was found in this study (between high and low consumers of sweetened beverages), and differences have previously been reported using similar methods. Differences between genders have previously been demonstrated by Tuomisto, Tuomisto, Hetherington and Lappalainen (1998) and Zylan (1996); differences between meal courses have previously been demonstrated by Hetherington (1996). The self-monitoring of reasons for the initiation and termination of eating have also previously been suggested useful in the treatment of obesity and eating disorders (Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998).

Assuming the methodology to be sufficiently sensitive however, differences between consumers were not found in the measurement of deliberate appetite control in this study, but were found in other measures and have been found previously. It may be, that differences in meal initiation and termination do not exist, whilst differences in appetite control do. It may be that the differences between consumers in appetite control that have previously been found are implemented not in starting and stopping eating but during eating. It may be that appetite is controlled not by controlling the start and the end of the eating episode, but by controlling the processes occurring within the eating episode - the foods consumed, the amount consumed, the reasons for continuing consumption, etc. Compared to the processes occuring within the eating episode, the reasons for starting and stopping eating may have very little effect on appetite (Mela and Rogers, 1998).

Alternatively, differences between consumers may be very small, or may remain undetected in this study due to the very small number of participants (48) who took part in the study and the very small amount of time (4 days) and number of eating episodes per participant (12 - 62) for which data were collected (Howell, 1997). The difference found in this study between high and low consumers of sweetened beverages in the proportion of eating episodes terminated for social reasons remains currently unexplained.

Considering both non-deliberate and deliberate controls of appetite, slight differences can also be seen in this study between male and female participants. In both measures, environmental stimuli were found to be much more influential in appetite control in male participants and in differences between male high and low consumers, than in female participants. An increased importance of environmental stimuli in the control of appetite in males has previously been reported (Zylan, 1996; Berry, 1982). No differences between males and females however, have also been reported (Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998; Beatty, Berry and Klesges, 1985).

12.4.4. ADDITIONAL FINDINGS

One other finding in this study is worthy of mention. Significant differences were found in this study, between all high and low consumers of artificially-sweetened beverages in the proportion of energy consumed from protein. High consumers consumed more energy from protein than low consumers. This finding however, is difficult to interpret meaningfully. No corresponding differences were found in the proportion of energy consumed from carbohydrate or fat, no differences were found only in male participants and differing significant differences were found only in female participants. These findings remain unexplained.

12.5. SUMMARY

In summary, this study has uncovered a number of interesting differences between high and low consumers of artificially-sweetened beverages. In measures of appetite, in both male and female participants, high consumers were found to consume a diet of lower energy density than low consumers. The consumption of a diet of lower energy density can be suggested as a deliberate means of appetite control. Female high consumers were also found to consume more fluids, and a greater frequency of sweetness. The high consumption of fluids is considered to be a further demonstration of a diet of low energy density, and cognitive appetite control. The high consumption of sweetness suggests an increased preference for sweetness in these consumers. In measures of non-deliberate appetite control, high and low consumers of artificially-sweetened beverages were found to be influenced by differing environmental stimuli. Those environmental stimuli more influential in appetite in the high consumers have previously been suggested to be more cognitive. All environmental stimuli were also found to be more influential in male participants, than in female participants. In measures of deliberate appetite control, no differences were found between high and low consumers of artificially-sweetened beverages. This lack of differences can be attributed to the probable lesser importance of reasons for meal initiation and termination in appetite control, compared to reasons for meal continuation. In conclusion, this study suggests that male and female high consumers are demonstrating more cognitive control over their appetite than male and female low consumers. Caution however, is required in the interpretation of these findings because of the possible low reliability and validity of data collected by food diaries.

Chapter 13.
DISCUSSION

The overall objective of this thesis was to investigate Uncoupling Sweetness and Energy in Habitual High Consumers of Artificial Sweeteners: Effects on Appetite and Appetite Control. Uncoupling sweetness and energy the habitual high consumption of artificial sweeteners, or the habitual high consumption of sweetness without energy may have a number of effects on appetite and appetite control. The effects of a single consumption of sweetness without energy on appetite have previously been widely investigated, and were demonstrated here in Study 1. The single consumption of sweetness without energy can stimulate appetite, although effects may be small. The effects of the habitual consumption of sweetness without energy have not been previously investigated. Uncoupling sweetness and energy in habitual high consumers of artificial sweeteners: effects on appetite and appetite control, were investigated in this thesis by comparing habitual high consumers of artificially-sweetened beverages with habitual low consumers. Habitual high and low consumers of artificially-sweetened beverages were defined in Study 2. Low consumers were also additionally defined following Study 4, as high consumers of non-sweetened beverages and high consumers of naturally-sweetened beverages to account for effects of fluid consumption and sweet fluid consumption. Effects on appetite - responses to sweetness, responses to energy, consumption of and preferences for sweetness, responses to sweetness intensity, consumption of and preferences for dietary fat content were investigated in Studies 3, 4, 5, 6, and 8. Effects on appetite control were investigated in Studies 7 and 8. All studies on appetite and appetite control are detailed individually in the previous chapters (Chapters 8, 9, 10, 11, and 12), and are summarized in Table 13.1. This chapter discusses all studies collectively. For reasons of space and clarity, only findings most relevant to the habitual consumption of sweetness without energy are included in Table 13.1, and only these findings will be discussed in this chapter. All other findings are discussed in the individual study chapters (Chapters 8, 9, 10, 11, and 12).

Before all findings are discussed however, it should be noted that all effects found in this thesis were found in small groups of participants (usually N=8) from a restricted population (University of Leeds, U.K.). Whilst these numbers are not atypical of experiments in appetite research, all effects should be interpreted cautiously.

13.1. FINDINGS

Table 13.1 can be found at the end of the chapter.

Considering all participants, differences are immediately apparent in Table 13.1, between male and female participants. In female participants, strong differences between high and low consumers of artificially-sweetened beverages were found in studies on appetite (measurements of hunger, food intake, food preferences), and in studies on appetite control (measurements of the means by which appetite is controlled - e.g. cognitive, emotional, environmental). In male participants, no differences between consumers were found in studies on appetite, and only weak differences between consumers were found in studies on appetite control.

13.1.1. FEMALE PARTICIPANTS

In female participants, as detailed in Table 13.1, a number of differences were found between high and low consumers of artificially-sweetened beverages in studies of appetite. Compared to low consumers, high consumers of artificially-sweetened beverages were found to demonstrate:

- higher levels of overall appetite (food intake) - Studies 3, 4;
- a decreased appetite (food intake) in response to energy, but no increased appetite (food intake) in response to sweetness; low consumers reported a decreased appetite (food intake) in response to energy and an increased appetite (food intake) in response to sweetness - Study 4;
- a decreased appetite for energy (subjective ratings) and an increased appetite for sweetness (subjective ratings) in response to non-sweet energy; low consumers reported a decreased appetite for energy (subjective ratings) and a decreased appetite for sweetness (subjective ratings) in response to non-sweet energy - Study 5;
- higher appetite (subjective ratings) for sweetness (similar responses in high consumers of naturally-sweetened beverages) - Study 5;
- higher appetite (food intake) for sweetness (similar responses in high consumers of naturally-sweetened beverages) - Study 5;
- an increased appetite (subjective ratings) following sweetness (similar responses in high consumers of naturally-sweetened beverages) - Study 5;
- an increased appetite (food intake) following sweetness - Study 3;
- higher appetite (subjective ratings) for fluids - Studies 3, 4, 5;
- higher appetite (fluid intake) for fluids - Study 8.

In studies on appetite control, compared to low consumers, high consumers of artificially-sweetened beverages were found to demonstrate:

- more highly restrained and more highly cognitively controlled eating attitudes and behaviours - Study 7;
- higher consumption of a diet of foods of low energy density - Study 8;
- more cognitively controlled eating behaviours - Study 8;

These findings suggest that, in female participants, compared to low consumers, the high consumption of artificially-sweetened beverages is associated with higher levels of overall appetite, differing responses to sweetness and energy, higher appetites for and following sweetness, higher appetites for fluids, and with a highly restrained and highly cognitively controlled eating style. Higher appetites for and following sweetness however, were not specific to the high consumption of artificially-sweetened beverages, but applied equally to high consumers of artificially-sweetened beverages and high consumers of naturally-sweetened beverages.

No evidence was found for a differing response to sweetness intensity in high and low consumers or a differing response to differing levels of dietary fat. No evidence thus was found for a habituation to sweetness in high consumers of artificially-sweetened beverages or for an increased consumption or preference for fat.

13.1.2. MALE PARTICIPANTS

In male participants, as detailed in Table 13.1, no differences were found between high and low consumers of artificially-sweetened beverages in studies on appetite. Differences were found in studies on appetite control. In studies on appetite control, compared to low consumers, high consumers of artificially-sweetened beverages were found to demonstrate:

- more highly restrained and more highly cognitively controlled eating attitudes and behaviours - Study 7;
- higher consumption of a diet of foods of low energy density - Study 8;
- more cognitively controlled eating behaviours - Study 8;

These differences were similar to those found in female participants, but were demonstrated to a lesser degree. These findings suggest that in male participants, compared to low consumers, the high consumption of artificially-sweetened beverages is associated with a highly restrained and highly cognitively controlled eating style.

13.2. EXPLANATIONS

Explanations can be provided for all these effects. Firstly, all effects found only in the high consumers of artificially-sweetened beverages can be explained as a result of the habitual uncoupling of sweetness and energy and can be understood with reference to the sweetness-energy relationship. The absence of such effects in male participants and the differences between male and female participants can also be explained with reference to the sweetness-energy relationship. Secondly however, the majority of effects in female participants, the lack of effects in male participants and the differences between male and female participants can also be explained by association with the active self-selection of a high consumption of artificial sweeteners, and may be unrelated to the uncoupling of sweetness and energy. Higher appetites for and following sweetness are clearly unrelated to the uncoupling of sweetness and energy, as are not specific to the high consumption of artificially-sweetened beverages. These effects can be explained as a result of high sweetness preferences and a high consumption of sweetness.

13.2.1. HIGH PREFERENCES FOR AND CONSUMPTION OF SWEETNESS

High appetites for sweetness and high appetites following sweetness can be explained as a result of high preferences for sweetness. High appetites for sweetness are unsurprising. High consumers of artificially-sweetened beverages are self-selecting to consume high quantities of sweetened foods. High appetites for sweetness and high preferences for sweetness would be expected (e.g. Laeng, Berridge and Butter, 1993). High appetites following sweetness can be explained as a result of a high perceived palatability for sweetness in the high consumers (Yeomans, Gray, Mitchell and True, 1997; Perez, Dalix, Guy-Grand and Bellisle, 1994; Hill, Magson and Blundell, 1984), as a result of high preferences for sweetness (Laeng, Berridge and Butter, 1993). High preferences for sweetness and a high perceived palatability of sweetness will also be perpetuated by a high consumption of sweetness (Pliner, Pelchat and Grabski, 1993). High appetites for and following sweetness thus are most likely to be a result of high preferences for sweetness, and may also in part be a result of the high consumption of sweetness. High levels of appetite for sweetness and following sweetness were found in response to all sweetened foods and in high consumers of all sweetened beverages.

13.2.2. THE HABITUAL UNCOUPLING OF SWEETNESS AND ENERGY

Higher levels of overall appetite, differing responses to sweetness and energy, higher appetites for fluids, and a highly restrained and cognitively controlled eating style in female high consumers of artificially-sweetened beverages can be explained as a result of the habitual uncoupling of sweetness and energy, and can be understood with reference to the sweetness-energy relationship - the reliable association between sweetness and the subsequent physiological effects of energy (see Chapter 1). As discussed in Chapter 3, in an environment where sweetness and energy are almost always consumed in association, the habitual uncoupling of sweetness and energy may directly result either in no change in the sweetness-energy relationship - a persistence of the relationship, or in an extinction of the sweetness-energy relationship. If the natural sweetness-energy relationship persists, the habitual consumption of sweetness without energy would be expected to result in habitual experiences of an increased appetite, possibly resulting either in increased consumption or an increased non-biological control of appetite (see Chapter 3, section 3.1.5.1). If the sweetness-energy relationship is extinguished, the habitual consumption of sweetness without energy would be expected to have no effects on appetite; consumption of sweetness with energy would be expected to affect appetite only by virtue of the included energy. This energy however, would be biologically unregistered until digestion. The extinction of the sweetness-energy relationship thus, would result in the loss of a biological control of appetite, possibly resulting in a less strict control of appetite or an increased reliance on other less appropriate means of appetite control (see Chapter 3, section 3.1.5.2). High levels of appetite for sweetness are also implicated in the habitual uncoupling of sweetness and energy. Due to the concurrent consumption of sweetness with energy, the habitual uncoupling of sweetness and energy is also suggested to result in the continued high consumption of sweetness (see Chapter 3, section 3.1.4).

High levels of overall appetite can be understood as a demonstration of a persistence of the sweetness-energy relationship. Differing responses to sweetness and energy can be understood as a demonstration of an extinction of the sweetness-energy relationship. Highly restrained and highly cognitively controlled eating attitudes and behaviours can be understood as a demonstration of an increased use of non-biological controls of appetite - a possible result both of a persistence and an extinction of the sweetness-energy relationship. High appetites for fluids can be considered to be an extension of the consumption of foods of low energy density, and are considered to be a further form of cognitive appetite control (see Alexander and Tepper, 1995; Tepper, 1992). A probable continued high consumption of sweetness is also demonstrated.

The absence of effects in male participants, and the differences between male and female participants can also be explained with reference to the sweetness-energy relationship. The absence of effects in males can be attributed to the reduced importance of taste in appetite in males. Reduced appetites for sweet tastes, following sweet tastes and for all tastes, were found in male participants in this thesis compared to female participants (Chapter 8, section 8.4; Chapter 11, section 11.4), and have been found elsewhere (e.g. Tuomisto, Tuomisto, Hetherington and Lappalainen, 1998; Yeomans, 1996; Zylan, 1996, Beatty, 1982).

The absence of effects in males however, may also be attributed not to the lack of effects on appetite of sweetness or the sweetness-energy relationship, but to the lack of a habitual consumption of sweetness without energy in the male high consumers. High consumers were defined in this thesis in absolute levels of consumption of artificially-sweetened beverages. This consumption may be at an ineffective level in male high consumers relative to overall food and fluid intake and body weight. Male high consumers were also found to consume only 21.8% of sweetness without energy. Differences between male high and low consumers may be found using more extreme consumers of sweetness without energy.

13.2.2.1. The Sweetness-Energy Relationship

In attempting to explain all findings in terms of the habitual uncoupling of sweetness and energy however, the probable underlying mechanisms of the sweetness-energy relationship - cephalic phase reflexes and associative conditioning, must also be considered.

The possible mechanisms behind a persistence and an extinction of the sweetness-energy relationship are provided in Chapter 3. These mechanisms can also explain the co-existence of a persistence and an extinction of the sweetness-energy relationship. Persistence of the sweetness-energy relationship may be achieved by cephalic phase reflexes and associative conditioning. Extinction of the sweetness-energy relationship may be achieved by associative conditioning. Persistence of the sweetness-energy relationship thus may be achieved by the cephalic phase reflexes and may act alongside an extinction of the sweetness-energy relationship by associative conditioning.

The possible mechanisms behind a persistence and an extinction of the sweetness-energy relationship can also suggest a probable persistence and extinction of the sweetness-energy relationship with reference to some of the findings in this thesis. In Chapter 3, persistence of the sweetness-energy relationship was considered to be a likely outcome of the habitual consumption of sweetness without energy as mediated by the cephalic phase reflexes. A persistence of the sweetness-energy relationship was also suggested as a likely outcome of the habitual consumption of sweetness without energy by associative conditioning if the initial relationship was strong, as would be expected for the sweetness-energy relationship. An extinction of the sweetness-energy relationship was suggested as a likely outcome of the habitual uncoupling of sweetness and energy by associative conditioning, if the consumption frequency of sweetness without energy was close to the consumption frequency of sweetness with energy, and if the duration of experience of sweetness without energy was long. In Study 8, female high consumers of artificially-sweetened beverages were found to consume almost equivalent levels of sweetness without energy and sweetness with energy (41.0% vs. 59.0% respectively). All participants were selected as habitual high consumers of artificially-sweetened beverages - i.e. consumed high quantities of artificially-sweetened beverages and had done so over an extended period of time.

The mechanisms underlying the sweetness-energy relationship can also account for the large variety in the effects of the habitual uncoupling of sweetness and energy on appetite and appetite control. As discussed in Chapter 3, the persistence and/or extinction of the sweetness-energy relationship will depend on the strength of the initial sweetness-energy relationship, consumption levels of sweetness both with and without energy, the duration of consumption of sweetness both with and without energy, and the continued consumption of sweetness both with and without energy. Differences between individuals, males and females, adults and children, and all investigatory studies can be potentially explained.

All explanations however should be treated with caution. Whilst all findings can be explained in terms of cephalic phase reflexes and associative conditioning theory, the role and importance of both as mediators of the sweetness-energy relationship are still currently far from clear.

13.2.3. SELF-SELECTION OF A HABITUAL HIGH CONSUMPTION OF ARTIFICIAL SWEETENERS

High levels of overall appetite, higher appetites for fluids and highly restrained and highly cognitively controlled eating attitudes and behaviours however, can also be explained by consideration of associations with the self-selection of a habitual high consumption of artificial sweeteners. Throughout this thesis, <u>associations</u> were found between high levels of overall appetite, higher appetites for fluids, and highly restrained and highly cognitively controlled eating attitudes and behaviours. These associations may occur not as a <u>result</u> of the habitual uncoupling of sweetness and energy as mentioned above; but may co-occur alongside the high uncoupling of sweetness and energy, related to the deliberate habitual high consumption of artificial sweeteners or may even precede that consumption.

The high consumption of artificially-sweetened beverages and artificial sweeteners has previously been highly associated and inter-related with a high B.M.I., high levels of restraint and a high cognitive control of appetite (e.g. Alexander and Tepper, 1995; Nabors and Lemieux, 1993). In this thesis, the high consumption of artificially-sweetened beverages was correctly predicted in 88% of cases by B.M.I. and weight preoccupation (Study 7). These findings suggest that a highly restrained and highly controlled eating style in the high consumers of artificially-sweetened beverages in this thesis may be explained by high levels of B.M.I. and high levels of weight preoccupation. Artificially-sweetened beverages are frequently considered to aid weight control, and may often be consumed as a response to or a prevention of a high B.M.I., and a high concern over weight. A high B.M.I. and concern over weight may lead to high levels of appetite and a high control of appetite.

A high B.M.I. may lead to high levels of appetite as a result of an increase in metabolic rate or an increase in metabolic costs as a result of a greater body size (see Mela and Rogers, 1998; Prentice, Goldberg, Murgatroyd and Cole, 1996).

A high cognitive control of appetite may lead to high levels of appetite. The high cognitive control of appetite is frequently correlated with high levels of disinhibition. A high disinhibition can lead to high levels of appetite (Herman and Mack, 1975). Disinhibition however can only plausibly explain overeating when normal appetite controls can not be exercised. Direct comparison of consumption in the laboratory and the field in this thesis suggest high consumers of artificially-sweetened beverages are not overeating (weight of food) when normal appetite controls can not be exercised, but are only overconsuming energy. This overconsumption of energy can be attributed to the energy density of the foods available in the laboratory and the necessary consumption from these foods (see Cooling and Blundell, 1998; Westerterp-Plantenga, Wijckmans-Duijsens, Verboeket-van de Venne, de Graaf, van het Hof and Westrate, 1998; Foltin, Fischman, Emurian and Rachlinski, 1988). Increases in appetite in high consumers of artificially-sweetened beverages thus may be a result of high levels of disinhibition, although may also be a result simply of the food choice available. Linked to the habitual consumption of a diet low in energy density, the higher appetite of the high consumers of artificially-sweetened beverages in the laboratory, may thus be further evidence of the high cognitive control of appetite in the natural world in these consumers. Restraint and disinhibition are also not always found to be related (e.g. see Westerterp-Plantenga, Kempen and Saris, 1998).

Associated with a high cognitive control of appetite, high levels of appetite in the high consumers of artificially-sweetened beverages may also be explained by high levels of physical activity. High levels of physical activity are frequently considered to aid weight loss or weight maintenance, and are often used alongside a high cognitive control of appetite (see Schoeller, Shay and Kushner, 1997). The relationship between physical activity and appetite in restrained individuals however is currently far from clear (Lluch, King and Blundell, 1998).

A high cognitive control of appetite has also been previously related to high levels of other non-biological controls of appetite - emotional eating and external eating (e.g. Wardle, Marsland, Sheikh, Quinn, Fedoroff and Ogden, 1992; van Strien, Frijters, Bergers and Defares, 1986). Emotional eating and external eating have previously been suggested to be associated with high levels of food intake and appetite (see Gorman and Allison, 1995).

Thus, whilst high levels of overall appetite and highly restrained and highly cognitively controlled eating attitudes and behaviours can be explained as a result of the habitual uncoupling of sweetness and energy, these effects may be more appropriately explained as a result of associations with the deliberate self-selection of a high consumption of artificial sweeteners as a result of a high body weight and concern over weight, and may even cause the high consumption of artificially-sweetened beverages. High levels of appetite and highly restrained and cognitively controlled eating attitudes and behaviours however, may also be perpetuated and increased by the habitual uncoupling of sweetness and energy. Indeed, in all laboratory studies, measures of B.M.I. and restrained eating were used as covariates in all appropriate analyses and can be considered as non-influential in all findings. B.M.I. and restraint (as measured by the D.E.B.Q. (van Strien, Frijters, Bergers and Defares, 1986)) however, may be considered to be only the very tip of the iceberg when considering the number and role of all other possible influences on appetite that may be associated with high levels of weight and weight concern. As discussed in Chapter 3, the effects on appetite of a highly restrained and cognitively controlled eating style may be very complex and are yet to be clearly understood (Mela and Rogers, 1998).

The lesser effects in appetite control in male participants and the differences between male and female participants in appetite control in this thesis can also be explained as a result of a lesser degree of concern over weight in male participants (Rolls, Fedoroff and Guthrie, 1991). A high B.M.I. and concern over weight however, do not explain the effects found in this thesis in appetite in male participants, nor do they explain the differing responses to sweetness and energy found in this thesis in appetite in female participants.

13.2.4. AN ADAPTATION TO SWEETNESS

Differing responses to sweetness and energy can only be plausibly explained as a result of the habitual uncoupling of sweetness and energy. Differing responses to sweetness and energy were only found in high consumers of artificially-sweetened beverages (i.e. were not found in high consumers of similar levels of other sweetened drinks or similar levels of low energy drinks). Differing responses to sweetness and energy are also very unlikely to precede the high consumption of artificially-sweetened beverages. Sweetness and energy are naturally associated in all individuals from a very early age (Beauchamp and Cowart, 1987), this association is reported to be easily learnt (Garcia, Hankins and Rusiniak, 1974), and will be continually maintained (see MAFF, 1995).

The demonstration of an extinction of the sweetness-energy relationship however, is a very interesting finding indeed. An extinction of the sweetness-energy relationship can be considered to be an adaptation to short term changes in the environment. Sweetness and energy are continually/habitually experienced in dissociation, and this dissociation is subsequently demonstrated. Sweetness and energy dissociated, sweetness will no longer result in the inappropriate anticipation of energy and will not result in inappropriate increases in appetite. The habitual consumption of sweetness without energy can thus be considered to result in an adaptation to sweetness. This adaptation however will also result in the loss of a biological control of appetite. This loss, as previously mentioned, may be expected to result either in a less controlled appetite, or an increased reliance on other less appropriate and less reliable means of appetite control. The increased use of (less appropriate and less reliable) non-biological controls was found in this thesis in association with the high consumption of artificially-sweetened beverages. Whether this increased use of non-biological controls is a result of the habitual uncoupling of sweetness and energy, however is unclear. The potential increased use of non-biological controls of appetite as a result of an extinction of the sweetness-energy relationship however, will only perpetuate any use of less appropriate non-biological controls of appetite that may already exist.

13.2.5. SUMMARY

Considering all findings and all explanations it may thus be suggested that the habitual high consumption of artificially-sweetened beverages is associated with high levels of overall appetite, differing responses to sweetness and energy, high appetites for fluids, high appetites for and following sweetness, and a highly restrained and highly cognitively controlled eating style in female participants, and with a highly restrained and highly cognitively controlled eating style to a lesser degree in male participants. High appetites for and following sweetness are explained in terms of preferences for and consumption of sweetness. High levels of overall appetite, differing responses to sweetness and energy, and a highly restrained and highly cognitively controlled eating style (including the high consumption of fluids) can be explained as a result of the habitual uncoupling of sweetness and energy in terms of the sweetness-energy relationship. High levels of appetite and a highly cognitively controlled eating style (including the high consumption of fluids) however may be more appropriately explained as a result of associations with the deliberate self-selection of artificial sweeteners - high levels of weight and a high concern over weight. These high levels of weight and concern over weight are more likely to co-occur or even precede, rather than cause the high consumption of artificially-sweetened beverages. High levels of weight and concerns over weight however can not explain differing responses to sweetness and energy. Differing responses to sweetness and energy are most plausibly explained in terms of the sweetness-energy relationship. Differing responses to sweetness and energy can be considered to demonstrate an extinction of the sweetness-energy relationship, and suggest an adaptation to sweetness. The lesser effects found in male participants may be a result of a lesser importance of taste in appetite regulation in males, or may be a result of a lesser concern over weight.

13.3. LIMITATIONS

From the discussion above, the work in this thesis can be seen to have two major limitations. Firstly, whilst the findings above demonstrate some clear effects on appetite of the habitual consumption of sweetness without energy, it is difficult to distinguish between effects generated by the uncoupling of sweetness and energy and effects generated by the habitual high consumption of artificially-sweetened beverages. Secondly, none of the effects found are necessarily causal. Whilst the findings above demonstrate some clear associations between uncoupling sweetness and energy in habitual high consumers of artificial sweeteners and differences in appetite and appetite control, causes and effects can not be distinguished between.

The effects on appetite of the habitual uncoupling of sweetness and energy, and the effects on appetite of the habitual consumption of artificially-sweetened beverages can be separated by investigation of the habitual consumption of sweetness without energy in consumers of other sources of sweetness without energy - chewing gum, sham-feeding; and investigation of the high consumption of artificially-sweetened beverages not involving the uncoupling of sweetness and energy - the high consumption of artificially-sweetened beverages only consumed in accompaniment with other energy sources. The causality of effects could be investigated using a longitudinal within-subjects design, measuring appetite before and after the habitual consumption of sweetness without energy by the habitual high consumption of artificially-sweetened beverages. These resolutions however have their own limitations - e.g. the effects on appetite of the absence of ingestion (see Chapter 7), the effects on normal behaviour of the highly controlled consumption of artificially-sweetened beverages only with other foods, the effects of time on appetite and appetitive behaviours. Completion of such investigations would also be very timely.

13.4. IMPLICATIONS

This work may have a number of implications, both of a theoretical and a practical nature.

Firstly, this research demonstrates the direct practical implications of effects of the habitual consumption of sweetness without energy on appetite and appetite control, when achieved by the high consumption of artificially-sweetened beverages - high levels of appetite, differing responses to sweetness and energy, and a highly restrained and highly cognitively controlled eating style. These effects could potentiate increases in obesity and increases in disturbed and disordered eating. Considering the current levels of use and consumption of sweetness without energy within the general population, and the likely increase in those consumption levels, these effects may be alarming. The potential severity of effects may also be further increased by the characteristics of the typical high consumer of sweetness without energy. In this thesis the high consumption of sweetness without energy was achieved by the high consumption of artificially-sweetened beverages. The majority of high consumers of artificially-sweetened beverages were consuming artificially-sweetened beverages as aids to weight loss or weight maintenance (see Chapter 1, section 1.2.1; Chapter 7, section 7.4). Potential increases in obesity or increases in disturbed and disordered eating however, will not aid weight loss. The high consumption of artificially-sweetened beverages thus, may not only fail to aid the control of weight loss and weight maintenance, but may perpetuate increases in weight and difficulties in weight control. The value of artificially-sweetened beverages as an aid to weight control is severely questioned. Increases in weight and difficulties in weight control may furthermore increase the use and consumption of artificially-sweetened beverages: the result - a vicious circle of increasing weight and increasing attempts to control that weight.

Secondly, on a more theoretical level, this research highlights an ability in humans to demonstrate the extinction of a learnt relationship in order to adapt to short-term changes in the environment. The ability to learn natural taste-consequence associations have been previously demonstrated (see Chapter 1, section 1.1.3). The demonstration of an extinction of a natural taste-consequence relationship however, has not been specifically demonstrated previously. This research sheds light on the ability in humans to demonstrate the extinction of a taste-consequence association in order to adapt to a changing environment. The findings of this research and the principles behind these findings may also be extended to other taste-consequence associations. Many taste-consequence associations may be similarly affected by current food processing procedures, food marketing techniques and current food products, and may have important effects on appetite and/or appetite control. Similar effects however, would depend on the similar complete dissociation of a taste and its consequences. Some evidence is also provided in this thesis for a possible dissociation between all tastes and energy. Further work however is clearly still needed here. As a practical implication, this research may be of considerable benefit in the understanding and treatment of food aversions and food avoidances, and in the understanding and treatment of food obsessions and addictions.

Finally, this research also demonstrates some important methodological considerations for appetite research. Strong differences were found in this thesis between appetite and appetite control in males and females. The importance of consideration of both males and females in appetite research is undeniable. Appetite and appetite control were also strongly influenced in this thesis by the habitual high consumption of artificially-sweetened beverages. Normal natural consumption patterns such as these, should be considered and controlled for in appetite research. Normal dietary consumption patterns may explain some of the effects and variety of effects on appetite and appetite control previously found (e.g. see Chapter 2).

13.5. CONCLUSION

In conclusion, this thesis has investigated Uncoupling Sweetness and Energy in Habitual High and Low Consumers of Artificial Sweeteners: Effects on Appetite and Appetite Control. Uncoupling sweetness and energy, the habitual high consumption of artificial sweeteners or the habitual high consumption of sweetness without energy has been found to have a number of effects on appetite and appetite control. The effects of a single consumption of sweetness without energy on appetite have previously been widely investigated, and were demonstrated here in Study 1. The single consumption of sweetness without energy can stimulate appetite, although effects may be small. The habitual consumption of sweetness without energy has not been previously investigated. The effects of the habitual consumption of sweetness without energy on appetite and appetite control were investigated in this thesis by comparing habitual high consumers of artificially-sweetened beverages with habitual low consumers.

Throughout this thesis, in female participants, habitual high consumers of artificially-sweetened beverages was found to be associated with high levels of overall appetite, differing responses to sweetness and energy, and highly restrained and cognitively controlled eating attitudes and behaviours. These findings can be explained as a result of the habitual uncoupling of sweetness and energy as a persistence and an extinction of the sweetness-energy relationship. High levels of overall appetite and a highly restrained and cognitively controlled eating style however can also be explained as a result of associations with the deliberate self-selection of a habitual high consumption of artificial sweeteners, and may be unrelated to the uncoupling of sweetness and energy. High levels of appetite and a highly cognitively controlled eating style (including the high consumption of fluids) may be more appropriately explained as demonstrations of associations with high levels of weight and high levels of concern over weight. A high B.M.I. and concern over weight are more likely to co-occur or even precede the high consumption of artificially-sweetened beverages than be a cause of it. A high B.M.I. or a high concern over weight however, can not explain differing responses to sweetness and energy. Differing responses to sweetness and energy can only be explained as a direct result of the habitual uncoupling of sweetness and energy - as a demonstration of an extinction of the sweetness-energy relationship. The extinction of the sweetness-energy relationship demonstrates a clear ability in humans to demonstrate the extinction of a taste-consequence association as an adaptation to changes in the environment. The habitual consumption of sweetness without energy thus, is associated with an adaptation to sweetness. In male participants, the habitual consumption of artificially-sweetened beverages was found to be associated with a restrained and cognitively controlled eating style, to a lesser degree than found in females. The lesser effects found in male participants may be a result of a lesser importance of taste in appetite regulation in males, or may be a result of a lesser concern over weight.

Uncoupling sweetness and energy in habitual high consumers of artificial sweeteners thus, is associated with various effects in appetite and appetite control. The majority of effects are considered to be a result of associations with the habitual high consumption of artificial sweeteners or more importantly, the deliberate self-selection of that consumption - high levels of B.M.I. and a high concern over weight. A minority of effects however can be considered to be a result of the habitual uncoupling of sweetness and energy, and may suggest the habitual uncoupling of sweetness and energy to be associated with an adaptation to sweetness.

Table 13.1: Review of All Studies in this Thesis Investigating the Habitual Consumption of Sweetness Uncoupled from Energy

Studies investigating Effects on Appetite				
Study	Aim	Design	Findings	Conclusions
Study 3 (Chp. 8)	Laboratory Study - to investigate the appetitive responses to sweetness and energy in habitual high and low consumers of artificially-sweetened beverages	2 x 2 x 3 mixed design gender (2) - Males, Females consumer (2) - HC, LC sweetness / energy manipulation preloads (3) - W, AS, NS	**Females**: • HC consumed significantly <u>more</u> in test meal intake following the AS preload and the NS preload than following the W preload, • LC consumed <u>similar</u> amounts in test meal intake following the W preload, the AS preload and the NS preload. **Males**: • No differences were found between HC and LC.	**Females:** • HC - increased appetite following sweetness, no responses to energy. • LC - no responses to sweetness or energy. **Males:** • LC, HC - no responses to sweetness or energy. No responses to sweetness or energy are attributed to methodology
Study 4 (Chp. 8)	Laboratory Study - to investigate the appetitive responses to sweetness and energy in habitual high and low consumers of artificially-sweetened beverages	2 x 2 x 3 mixed design gender (2) - Males, Females consumer (2) - HC, LC sweetness / energy manipulation preloads (3) - W, AS, NS	**Females**: • HC consumed significantly <u>more</u> in test meal intake than LC. • HC reported <u>higher</u> levels of thirst than LC. • LC demonstrated responses to sweetness and energy, HC demonstrated responses to energy, but no responses to sweetness. **Males**: • HC consumed similar amounts in test meal intake to LC. • HC demonstrated responses to sweetness and energy, LC demonstrated no responses to sweetness or energy.	**Females:** • HC - higher levels of overall appetite. • HC - higher appetite for fluids. • HC - dissociation between responses to sweetness and responses to energy. • LC - lower levels of appetite, responses to sweetness and energy. **Males:** • LC, HC - differing responses to sweetness and energy. Differing responses in males are attributed to methodology.

Consumers: - HC = High Consumers of Artificially-Sweetened Beverages; LC = Low Consumers of Artificially-Sweetened Beverages;
AC = High Consumers of Artificially-Sweetened Beverages; WC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Non-Sweet/Low Energy beverages; NC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Naturally-Sweetened Beverages.
Preloads: - W = Non-Sweet/Low Energy preload; AS = Sweet/Low Energy Preload; NS = Sweet/High Energy Preload

Table 13.1 continued: Review of All Studies in this Thesis Investigating the Habitual Uncoupling of Sweetness and Energy continued

Studies investigating Effects on Appetite				
Study	Aim	Design	Findings	Conclusions
Study 5 (Chp. 9)	Laboratory Study - to investigate the appetitive responses to sweetness in solid form in habitual high and low consumers of artificially-sweetened beverages	2 x 3 x 2 mixed design gender (2) - Males, Females consumer (3) - WC, AC, NC sweetness manipulation preloads (2) - Sweet, Non-Sweet	**Females**: • AC and NC reported a higher appetite for something sweet than WC. • Compared to WC, AC and NC reported differing responses to the sweet and the non-sweet lunch. WC reported mainly similar responses to the two lunches • AC reported higher levels of thirst than WC and NC. • Compared to the WC and NC, AC reported an increase in appetite for something sweet following the non-sweet lunch compared to baseline measures. WC and NC reported a decrease in appetite for something sweet following the non-sweet lunch compared to the baseline measures. **Males**: • No differences were found between WC, AC and NC.	**Females:** • AC, NC - higher appetite for sweetness. • AC, NC - higher appetite following sweetness. • WC - lower appetite for and following sweetness. • AC - higher appetite for fluids. • AC - dissociation between sweetness and energy. • WC, NC - lower appetite for fluids, associated responses to sweetness and energy. **Males:** • W, NC, AC - no differences.
Study 6 (Chp. 10)	Laboratory Study - to investigate the appetitive response to sweetness, sweetness intensity and dietary fat content in habitual high and low consumers of artificially-sweetened beverages.	2 x 3 x 5 x 4 mixed design gender (2) - Males, Females consumer (3) - WC, AC, NC sweetness intensity (5) - 0%, 5%, 10%, 15%, 20% dietary fat content (4) - 0.1%, 4.0%, 18.0%, 48.0%	**Females**: • No differences were found between WC, AC and NC. **Males**: • No differences were found between WC, AC and NC.	**Females:** • WC, NC, AC - no evidence for differing responses to sweetness or fat. **Males:** • WC, NC, AC - no evidence for differing responses to sweetness or fat. No differences in responses to sweetness and fat are attributed to methodology

Consumers: - AC = High Consumers of Artificially-Sweetened Beverages; WC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Non-Sweet/Low Energy beverages; NC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Naturally-Sweetened Beverages.

Table 13.1 continued: Review of All Studies in this Thesis Investigating the Habitual Uncoupling of Sweetness and Energy continued

Studies investigating Effects on Appetite and Appetite Control				
Study	Aim	Design	Findings	Conclusions
Study 7 (Chp. 11)	Questionnaire Study - to investigate the general eating attitudes, patterns and behaviours in habitual high and low consumers of artificially-sweetened beverages	2 x 3 mixed design gender (2) - Males, Females consumer (3) - WC, AC, NC scales of eating attitudes, patterns and behaviours (14) - B.M.I. D.E.B.Q. (3 scales), Y.E.P.Q. (6 scales), E.D.I. (4 scales).	**Females**: • AC reported significantly higher levels of B.M.I., Restrained Eating, significantly higher tendencies toward Bingeing, Body Dissatisfaction, Weight Preoccupation, Anorexia Nervosa Restrictor Type, Anorexia Nervosa Bulimia Type, compared to WC and NC. **Males**: • AC reported significantly higher levels of B.M.I., Restrained Eating, significantly higher tendencies toward Body Dissatisfaction, Weight Preoccupation, compared to NC, and Anorexia Nervosa Restrictor Type, Anorexia Nervosa Bulimia Type, compared to WC. **Females and Males**: • Differences between AC, and WC and NC could be predicted in a logistic regression equation by B.M.I. and E.D.I.- Weight Preoccupation.	**Females:** • AC - higher B.M.I. and more highly restrained and cognitively controlled eating attitudes and behaviours • WC, NC - lower B.M.I. and less highly restrained and cognitively controlled eating attitudes and behaviours **Males:** • AC - higher B.M.I. and more highly restrained and cognitively controlled eating attitudes and behaviours • WC, NC - lower B.M.I. and less highly restrained and cognitively controlled eating attitudes and behaviours **Females and Males**: • Differences in B.M.I. and restrained and cognitively controlled eating attitudes and behaviours predicted by B.M.I. and weight preoccupation Less Effects in Males than Females

Consumers: - AC = High Consumers of Artificially-Sweetened Beverages; WC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Non-Sweet/Low Energy beverages; NC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Naturally-Sweetened Beverages.

Table 13.1 continued: Review of All Studies in this Thesis Investigating the Habitual Uncoupling of Sweetness and Energy continued

Studies investigating Effects on Appetite and Appetite Control				
Study	Aim	Design	Findings	Conclusions
Study 8 (Chp. 12)	Field Study - to investigate specific eating patterns and behaviours in habitual high and low consumers of artificially-sweetened beverages	2 x 3 mixed design gender (2) - Males, Females consumer (3) - WC, AC, NC measures of specific eating patterns and behaviours (5) - quantity consumed (overall, sweet foods, dietary fat), environmental stimuli, and reasons for meal initiation and termination	**Females**: • AC consumed more weight of food and total weight than WC and NC (trend). • AC consumed less energy than WC and NC (trend). • AC consumed a similar frequency of sweetened food items as NC, but consumed a greater frequency of sweetened food items than WC. • AC consumed a similar proportion of energy from fat as WC and NC. **Males**: • AC consumed similar weight of food and total weight as WC and NC • AC consumed less energy than WC and NC (trend). • AC consumed a similar frequency of sweetened food items as NC, but consumed a greater frequency of sweetened food items than WC. • AC consumed a similar proportion of energy from fat as WC and NC. **Females and Males**: • AC reported a stronger relationship between energy intake and relation of all other individuals and classification of each eating episode than WC and NC. • AC reported a weaker relationship between energy intake and number of all other individuals, the location and duration of the eating episode than WC and NC.	**Females:** • AC - higher appetite for fluids. • AC - higher appetite for sweetness. • AC - consumed diet of lower energy density considered to be a cognitively controlled eating behaviour. • WC, NC - lower appetites for fluids, and for sweetness. Consumed diet of higher energy density. **Males:** • AC - consumed diet of lower energy density • WC, NC - lower appetites for fluids, and for sweetness. Consumed diet of higher energy density considered to be a cognitively controlled eating behaviour. **Females and Males**: • AC - more highly restrained and more cognitively controlled eating behaviours. • WC, NC - less highly restrained and more cognitively controlled eating behaviours. Less Effects in Males than Females

Consumers: - AC = High Consumers of Artificially-Sweetened Beverages; WC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Non-Sweet/Low Energy beverages; NC = Low Consumers of Artificially-Sweetened Beverages, but High Consumers of Naturally-Sweetened Beverages.

EPILOGUE

The work in this thesis investigates 'Uncoupling Sweetness and Energy in Habitual High and Low Consumers of Artificial Sweeteners: Effects on Appetite and Appetite Control'. Whilst between-group comparisons were necessitated by the nature of the research, little account has been taken in this work of the possible effects of within-group effects. Individual differences between participants may account for some of the effects found. This epilogue reanalyses data presented in the thesis to consider this possibility.

14.1. INDIVIDUAL DIFFERENCES

Appetite and appetite control may be influenced by numerous differences between individual participants, both physiological, e.g. B.M.I., B.M.R., body fat mass, lean tissue mass; and psychological, e.g. cognitions, emotions, environmental stimuli (see Mela and Rogers, 1998). Of particular importance when investigating appetite in relation to taste, appetite and appetite control may also be influenced by differences between individuals in taste detection and taste perception. Differences in taste detection and perception have previously been reported between genders (e.g. Tordoff and Alleva, 1990b), between age groups (e.g. Zallen, Hooks and O'Brien, 1990), between lean and obese (see Drewnowski, 1987), and between 'tasters' and 'non-tasters' - a difference between persons in the ability to taste the chemical compound - phenylthiocarbamide. Compared to 'non-tasters', 'tasters' are reported to perceive bitter compounds as more intensely bitter, natural sweeteners as more intensely sweet, and artificial sweeteners as bitter (Hess, 1997; Duffy, 1996).

Effects on appetite may be explained by any number of individual differences. This reanalysis aims to investigate the importance of individual differences in explaining the effects found previously throughout this thesis. Data from one study - Study 5, will be reanalysed to consider effects of experimental manipulation - gender, consumer type and preload; and effects of individual differences - B.M.I., restraint, detections and perceptions of taste. All effects found in this reanalysis will be compared to original findings.

14.2. STUDY 5: Uncoupling Sweetness and Energy in Habitual High Consumer RESPONSES TO SWEETNESS WHEN CONSUMED AS A MEAL

The study investigates the appetitive responses to sweetness in solid form in habitual high and low consumers of artificially-sweetened beverages. The study uses a 2 x 3 x 2 mixed design, investigating gender (2 levels), consumers type (3 levels), and sweetness manipulation preload (2 levels). Appetite was measured using subjective and behavioural measures. Details of the Methodology of Study 5 are provided in Chapter 9, section 9.2.

14.2.1. REANALYSIS

This reanalysis aims to investigate the importance of experimental manipulations and individual differences in appetite. Reanalysis will be conducted using Pearson Product Moment Correlations and Multiple Regression.

14.2.1.1. Independent Variables

Gender, Consumer type, Preload, ratings of Pleasantness, ratings of Tastiness, ratings of Sweetness, ratings of Saltiness: Prior to reanalysis of all data in this study, all correlations between all independent variables were investigated using Pearson Product Moment Correlations. All significant correlations are borne in mind throughout all analyses. All strong correlations are thoroughly investigated before future analyses to ensure against violations of any of the assumptions of multiple regression.

14.2.1.2. Dependent Variables

Subjective Measures of Appetite: All subjective measures of appetite are reanalysed using Pearson Product Moment Correlations and Multiple Regression (enter method): dependent variables: Area Under the Curve (A.U.C.) (Hulshof, de Graaf and Westrate, 1993) for each measure of appetite; independent variables: experimental manipulations - gender, consumer type, preload; individual differences - B.M.I., dietary restraint and ratings of tastiness.

Behavioural Measures of Appetite: All behavioural measures of appetite are reanalysed using Pearson Product Moment Correlations and Multiple Regression (enter method): dependent variables - weight of food consumed (gram.), energy consumed (kcal.), proportions of all macronutrients consumed (%kcal.), measured individually and cumulatively across the day; independent variables - gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness.

For all analyses, consumer type was split into two variables: consumer-sweet (consumer of non-sweetened / sweetened beverages) and consumer-energy (consumer of low / high energy beverages). The following codes were used for dichotomous variables: gender - males = 1, females = 2; consumer-sweet - low consumer of sweetened beverages = 1, high consumer of sweetened beverages = 2; consumer-energy - low consumer of high energy beverages = 1, high consumer of low energy beverages = 2; preload - sweet lunch = 1, non-sweet lunch = 2. All participants were used in all analyses, due to the number of cases required for regressions.

14.2.2. RESULTS

14.2.2.1. Independent Variables

Prior to analysis of the dependent variables in this study, significant correlations were found between many of the independent variables. A correlation matrix for all independent variables is given in Figure 14.1.

Figure 14.1: Correlation Matrix for Correlations between All Potential Influences on Appetite (N=96) (significant correlations in bold)

	Gender	ConsS	ConsE	Preload	B.M.I.	Res	Pleas	Taste	Sweet	Salt
Gender	1.0000									
	P= .									
ConsS	.0000	1.0000								
	P=1.000	P= .								
ConsE	.0000	**.5000**	1.0000							
	P=1.000	**P< .001**	P= .							
Preload	.0000	.0000	.0000	1.0000						
	P=1.000	P=1.000	P=1.000	P= .						
B.M.I.	-.1968	**.2341**	.0315	.0000	1.0000					
	P= .055	**P= .022**	P= .761	P=1.000	P= .					
Res	**.5103**	.1219	**-.2785**	.0000	.1102	1.0000				
	P< .001	P= .237	**P= .006**	P=1.000	P= .285	P= .				
Pleas	.0888	-.1756	.0151	**-.2489**	.0688	-.1152	1.0000			
	P= .390	P= .087	P= .884	**P= .014**	P=.506	P=.264	P= .			
Taste	.0933	-**.2143**	.0707	.0441	.0562	-.1134	**.7637**	1.0000		
	P= .366	**P= .036**	P= .494	P= .670	P= .587	P= .271	**P< . 001**	P= .		
Sweet	-.0356	.0015	.0079	**-.9453**	-.0012	-.0209	**.3169**	-.0287	1.0000	
	P= .731	P= .988	P= .941	**P< .001**	P= .991	P= .840	**P= .002**	P= .781	P= .	
Salt	-.0393	.0723	.0645	**.8629**	.0899	-.0706	**-.2489**	-.0371	**-.8509**	1.000
	P= .704	P= .484	P= .532	**P< .001**	P= .384	P= .494	**P= .014**	P= .719	**P< .001**	P= .

Key: Gender – Gender; ConsS – Consumer-Sweet; ConsE – Consumer-Energy; Preload – Preload; B.M.I. – B.M.I.; Res – Restraint; Pleas – Ratings of Pleasantness; Taste – Ratings of Tastiness; Sweet – Ratings of Sweetness; Salt – Ratings of Saltiness

The highest correlations were observed, firstly, between preload and ratings of pleasantness ($r=-0.249$, $p=0.01$), ratings of sweetness ($r=-0.945$, $p<0.001$) and ratings of saltiness ($r=0.863$, $p<0.001$) - consumption of a sweet lunch was associated with higher ratings of pleasantness, higher ratings of sweetness and lower ratings of saltiness. Secondly, ratings of pleasantness were very highly correlated with ratings of tastiness ($r=0.764$, $p<0.001$), ratings of sweetness ($r=0.317$, $p=0.002$) and ratings of saltiness ($r=-0.249$, $p=0.01$). Ratings of sweetness were also highly correlated with ratings of saltiness ($r=-0.851$, $p<0.001$). These strong associations between preload, ratings of pleasantness, ratings of tastiness, ratings of sweetness and ratings of saltiness may have implications for all regression analyses. To ensure against effects of multicolinearity, all regression analyses were conducted including only preload and ratings of tastiness as regressors. Inclusion of ratings of pleasantness, sweetness and saltiness resulted in strong multicolinearity effects.

High correlations were also found between gender and restraint ($r=0.510$, $p<0.001$) - males were less restrained than females; and between consumer-sweet and consumer-energy ($r=0.500$, $p=0< 0.001$) - high consumers of sweetened beverages were more likely to be high consumers of high energy drinks (a function of the specific groups selected for the study). Correlations were also found between consumer-sweet and B.M.I. ($r=0.234$, $p=0.02$) and ratings of taste ($r=-0.214$, $p=0.04$), and consumer-energy and restraint ($r=-0.279$, $p=0.01$). High consumers of sweetened beverages were associated with a higher B.M.I. and lower ratings of taste. High consumers of high energy beverages were associated with a lower restraint. These correlations are borne in mind when considering all future analysis. None of these variables, however, were removed from further analysis.

14.2.2.2. Dependent Variables - Subjective Measures of Appetite

A combined correlation matrix for correlations between each subjective measure of appetite (dependent variables) and all measured potential influences on appetite (independent variables) is given in Figure 14.2. Correlations between all subjective measures of appetite are not included; all measures were considered separately, but are combined in the figure to avoid repetition of participants characteristics.

Subjective Measures of Hunger:

On initial analysis of Study 5, significant differences were found in subjective measures of hunger only between genders. Males reported a greater hunger than females.

On reanalysis, significant correlations were found in the subjective measures of hunger between hunger, desire to eat, prospective consumption and gender (smallest $r=-0.204$, $p=0.05$), between fullness and consumer-sweet ($r=0.208$, $p=0.04$), between hunger and B.M.I. ($r=0.209$, $p=0.04$), and between desire to eat, fullness, prospective consumption and restraint (smallest $r=0.216$, $p=0.04$). A greater hunger was associated with being male, being a high consumer of sweetened beverages, greater B.M.I., and higher restraint. These findings suggest subjective measures of hunger are influenced by both experimental manipulations – gender and consumer, and individual differences – B.M.I. and restraint.

Figure 14.2: Correlation Matrix for Correlations between All Potential Influences on Appetite and All Subjective Measures of Appetite (N=96) (significant correlations in bold)

	Gender	ConsS	ConsE	Preload	B.M.I.	Res	Pleas	Taste	Sweet	Salt
Hunger	**-.2035**	.0282	-.1910	-.0542	**.2087**	-.0523	-.1011	-.0941	.0611	.0041
	P= .047	P= .785	P= .062	P= .600	**P= .041**	P= .613	P= .327	P= .362	P= .554	P= .969
D E	**-.3698**	-.0458	-.0638	-.1095	-.0087	**-.3023**	-.0864	-.1271	0.1476	-.0203
	P< .001	P= .658	P= .537	P= .288	P= .933	**P= .003**	P= .403	P= .217	P= .15	P= .845
Fullness	.1180	**.2083**	.0879	.1482	.0881	**.2155**	.0437	.0729	-.1565	.1332
	P= .252	**P= .042**	P=.394	P= .150	P= .393	**P= .035**	P=.673	P= .480	P=.128	P= .196
P C	**-.2175**	-.0202	.0523	-.1343	.0054	**-.2801**	-.0004	-.1038	.1791	-.1016
	P= .033	P= .845	P= .613	P= .192	P= .958	**P= .006**	P= .997	P= .314	P= .081	P= .324
Thirst	-.1872	**.2339**	-.1472	.1121	**.2110**	.0295	**-.2203**	-.1382	-.1249	.1497
	P= .068	**P= .022**	P= .152	P= .277	**P= .039**	P= .776	**P= .031**	P= .179	P= .225	P= .145
D D	-.1660	**.2267**	-.1537	.0778	.1920	.0189	-.2316	-.1662	-.0854	.1436
	P= .106	**P= .026**	P= .135	P= .451	P= .061	P= .855	P= .023	P= .106	P= .448	P= .163
Sweet	-.0198	**.3164**	.0282	**.3462**	-.0083	.0648	-.0433	.0490	**-.3036**	**.3150**
	P= .848	**P= .002**	P= .785	**P= .001**	P= .936	P= .531	P=.676	P= .635	**P= .003**	**P= .002**
Savoury	**-.2787**	-.0523	.0095	**-.3377**	-.0745	**-.2283**	**-.0976**	**-.2146**	**.3870**	**-.2696**
	P= .006	P= .613	P= .927	**P= .001**	P= .471	**P= .025**	P=.344	**P= .036**	**P< .001**	**P= .008**
Meal	**-.3109**	-.0342	-.0828	-.1550	.1024	-.1748	-.0399	-.1705	.1797	-.0818
	P= .002	P= .740	P=.423	P= .132	P= .321	P= .088	P= .699	P= .097	P= .080	P= .428

Key: Gender – Gender; ConsS – Consumer-Sweet; ConsE – Consumer-Energy; Preload – Preload; B.M.I. – B.M.I.; Res – Restraint; Pleas – Ratings of Pleasantness; Taste – Ratings of Tastiness; Sweet – Ratings of Sweetness; Salt – Ratings of Saltiness; Subjective Measures of: Hunger – Hunger; D E – Desire to Eat; Fullness – Fullness; P C – Prospective Consumption; Thirst – Thirst; D D – Desire to Drink; Sweet – Appetite for Something Sweet; Savoury – Appetite for Something Savoury; Meal – Appetite for a Meal.

Subjective Measures of Hunger:

Considering all variables in a multiple regression, a significant regression equation was found only for measures of Desire to Eat (A.U.C.) (Hunger - R^2= 0.134, adj R^2= 0.065, F(7,88)=1.94, p=0.07; **Desire to Eat - R^2= 0.193, adj R^2= 0.129, F(7,88)=3.01, p=0.01;** Fullness - R^2= 0.121, adj R^2= 0.051, F(7,88)=1.73, p=0.11; Prospective Consumption - R^2= 0.119, adj R^2= 0.049, F(7,88)=1.70, p=0.12). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, desire to eat was significantly predicted by gender (Beta(88)=-0.252, p=0.04) (see Table 14.1). Similar patterns were found in all subjective measures of hunger, although did not reach statistical significance (see Appendix 14.1). These findings suggest that the effects of gender previously found, to be effects of gender only. These effects were not the result of any individual differences.

Table 14.1: Results of Regression Equation for Subjective Measures of Desire to Eat.

Regressor	Beta	significance
Gender	**-0.252**	**0.04**
Consumer-sweet	0.033	0.79
Consumer-energy	-0.134	0.29
Preload	0.105	0.28
B.M.I.	-0.031	0.77
Restraint	-0.224	0.09
Tastiness	-0.106	0.31

Subjective Measures of Thirst:

On initial analysis of Study 5, significant differences were found in subjective measures of thirst between consumers and between preloads. A greater thirst was reported in high consumers of artificially-sweetened beverages and following the non-sweet lunch.

On reanalysis, significant correlations were found in subjective measures of thirst between thirst and desire to drink and consumer-sweet (smallest r=0.227, p=0.03) and between thirst and B.M.I. (r=0.211, p=0.04) and ratings of pleasantness (r=-0.220, p=0.03). A greater thirst was associated with being a high consumer of sweetened beverages, a greater B.M.I, and lower ratings of pleasantness.

On entering all variables into a multiple regression, significant regression equations were found for measures of Thirst (A.U.C.) (**R^2=0.208, adj R^2= 0.145, F(7,88)=3.30, p=0.004**) and Desire to Drink (A.U.C.) (**R^2=0.197, adj R^2= 0.133, F(7,88)=3.08, p=0.006**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of thirst were consumer-sweet (Beta(88)=0.389, p=0.002) and consumer-energy (Beta(88)=-0.363, p=0.005) (see Table 14.2). A greater thirst was predicted by being a high consumer of sweet beverages and a high consumer of low energy beverages - i.e. a high consumer of sweet / low energy (artificially-sweetened) beverages. Similar patterns were found in subjective measures of desire to drink (see Appendix 14.1). These findings suggest that the effects found in the previous analysis of consumer and preload, can be attributed to consumer only. Effects in subjective measures of thirst were not the result of any of the individual differences.

Table 14.2: Results of Regression Equation for Subjective Measures of Thirst

Regressor	Beta	significance
Gender	-0.123	0.31
Consumer-sweet	**0.389**	**0.002**
Consumer-energy	**-0.363**	**0.005**
Preload	0.114	0.23
B.M.I.	0.117	0.26
Restraint	-0.074	0.57
Tastiness	-0.038	0.71

Subjective Measures of Appetite for Something Sweet:

On initial analysis, significant differences were found in the subjective measures of appetite for something sweet between consumers and between preloads. A higher appetite for something sweet was reported by high consumers of sweetened beverages and following a non-sweet lunch.

On reanalysis, subjective measures of appetite for something sweet were significantly correlated with consumer-sweet (r=0.316, p=0.002), preload (r=0.346, p=0.001), ratings of sweetness (r=-0.304, p=0.003) and ratings of saltiness (r=0.315, p=0.002). A higher appetite for something sweet was associated with being a high consumer of sweetened beverages, consuming a non-sweet lunch, with lower ratings of sweetness and higher ratings of saltiness.

On entering all variables into a regression, a significant regression equation was found for measures of Appetite for Something Sweet (A.U.C.) (**R^2= 0.280, adj R^2= 0.223, F(7,88)=4.89, p=0.0001**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of appetite for something sweet were consumer-sweet (Beta(88)=0.498, p=0.0001) and preload (Beta(88)=0.339, p=0.0003) (see Table 14.3). A greater appetite for something sweet was predicted by being a high consumer of sweetened beverages and consuming a non-sweet lunch. These findings suggest that the effects of consumer and preload found previously are effects solely of consumer and preload, and are not a result of any of the individual differences studied here.

Table 14.3: Results of Regression Equation for Subjective Measures of Appetite for Something Sweet

Regressor	Beta	Significance
Gender	-0.071	0.54
Consumer-sweet	**0.498**	**0.0001**
Consumer-energy	-0.225	0.06
Preload	**0.339**	**0.0003**
B.M.I.	-0.143	0.15
Restraint	0.013	0.92
Tastiness	0.173	0.08

Subjective Measures of Appetite for Something Savoury:

On initial analysis, significant differences were found in subjective measures of appetite for something savoury between preloads. A greater appetite for something savoury was reported following the sweet lunch.

On reanalysis, subjective measures of appetite for something savoury were significantly correlated with gender (r=-0.279, p=0.006), preload (r=-0.338, p=0.001), restraint (r=-0.228, p=0.03), ratings of tastiness (r=-0.215, p=0.04), ratings of sweetness (r=0.387, p<0.001) and ratings of saltiness (r=-0.270, p=0.008). A higher appetite for something savoury was associated with being male, consuming a sweet lunch, lower restraint, lower ratings of tastiness, higher ratings of sweetness and lower ratings of saltiness.

On entering all variables into a multiple regression, a significant equation was found for measures of Appetite for Something Savoury (A.U.C.) (**R^2= 0.252, adj R^2= 0.193, F(7,88)=4.24, p=0.0004**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of appetite for something savoury were preload (Beta(88)=-0.328, p=0.0006) and ratings of tastiness (Beta(88)=-0.209, p=0.04) (see Table 14.4). A greater appetite for something savoury was predicted by consuming a sweet lunch and lower ratings of tastiness. These findings suggest effects of preload as previously found in appetite for something savoury are a result of effects of preload and effects of ratings of tastiness. Effects in subjective measures of appetite for something savoury thus were a result of individual differences as well as experimental variables.

Table 14.4: Results of Regression Equation for Subjective Measures of Appetite for Something Savoury

Regressor	Beta	Significance
Gender	-0.216	0.07
Consumer-sweet	-0.084	0.48
Consumer-energy	0.038	0.76
Preload	**0.328**	**0.0006**
B.M.I.	-0.074	0.46
Restraint	-0.113	0.37
Tastiness	**-0.209**	**0.04**

Subjective Measures of Appetite for a Meal:

On initial analysis, significant differences were found in subjective measures of appetite for a meal between preloads. A greater appetite for a meal was found following a sweet lunch.

On reanalysis, appetite for a meal was significantly correlated with gender (r=-0.311, p=0.002). A higher appetite for a meal was associated with being male.

On entering all variables into a multiple regression, a significant equation was found for measures of Appetite for a Meal (A.U.C.) (**R^2= 0.156, adj R^2= 0.089, F(7,88)=2.33, p=0.03**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, however there were no significant predictors of appetite for a meal (largest Beta(88)=-0.221, p=0.08) (see Table 14.5). The findings suggest the effects of preload found previously was an independent effect of none of the experimental manipulations or individual differences.

Table 14.5: Results of Regression Equation for Subjective Measures of Appetite for a Meal

Regressor	Beta	significance
Gender	-0.221	0.08
Consumer-sweet	-0.031	0.80
Consumer-energy	-0.089	0.49
Preload	-0.148	0.13
B.M.I.	0.090	0.40
Restraint	-0.111	0.41
Tastiness	-0.161	0.13
Sweetness	0.248	0.42

14.2.2.3. Dependent Variables - Behavioural Measures of Appetite

A combined correlation matrix for correlations between each behavioural measures of appetite (dependent variables) and all measured potential influences on appetite (independent variables) is given in Figure 14.3. Correlations between all behavioural measures of appetite are not included; all measures were considered separately, but are combined in the table to avoid repetition of participants characteristics.

Figure 14.3: Correlation Matrix for Correlations between All Potential Influences on Appetite and All Behavioural Measures of Appetite (N=96) (significant correlations in bold)

	Gender	ConsS	ConsE	Preload	B.M.I.	Res	Pleas	Taste	Sweet	Salt
W - D	**-.4940**	-.0213	.1018	-.0770	**.3663**	**-.4334**	.1324	0.1118	0.1330	.1396
	P< .001	P= .837	P= .324	P= .456	**P< .001**	**P< .001**	P=.199	P= .278	P= .197	P= .175
W - E	**-.2892**	-.1830	-.0348	-.0536	.1844	**-.2258**	.1618	.1753	.0154	-.0740
	P= .004	P= .074	P= .736	P= .604	P= .072	**P= .027**	P= .115	P= .088	P= .881	P= .474
W - FD	**-.6147**	-.0232	.0941	-.0307	**.3255**	**-.4880**	.0947	.1130	.0939	.0688
	P< .001	P= .823	P= .362	P= .766	**P= .001**	**P< .001**	P= .359	P= .273	P= .363	P= .505
W - EoD	**-.5328**	-.0861	.0761	-.0197	**.2945**	**-.4549**	.1312	.1812	.0526	.0278
	P< .001	P= .404	P= .461	P= .849	**P= .004**	**P< .001**	P= .203	P= .077	P= .061	P= .788
E - D	**-.4004**	-.0970	.0134	-.0774	**.3558**	**-.3268**	.1219	.1633	.1249	-.0060
	P< **.001**	P= .347	P= .897	P= .453	**P< .001**	**P= .001**	P= .237	P= .112	P= .225	P= .953
E - E	**-.2632**	-.1170	.0485	-.0523	.1684	**-.2458**	.1275	.1222	.0224	-.0509
	P= .010	P= .256	P= .639	P= .613	P= .101	**P= .016**	P= .216	P= .235	P= .829	P= .622
E - FD	**-.6007**	-.0687	.0178	-.0290	**.3430**	**-.4369**	.1351	.1074	.0782	-.0574
	P< .001	P= .506	P= .863	P= .779	**P= .001**	**P< .001**	P= .189	P=.298	P=0.449	P= .578
E - EoD	**-.4763**	-.1173	.0436	-.0516	**.2850**	**-.3858**	.1566	.1395	.0534	-.0642
	P< .001	P= .255	P= .673	P= .617	**P= .005**	**P< .001**	P= .128	P= .175	P= .605	P= .534

Key: Gender – Gender; ConsS – Consumer-Sweet; ConsE – Consumer-Energy; Preload – Preload; B.M.I. – B.M.I.; Res – Restriant; Pleas – Ratings of Pleasantness; Taste – Ratings of Tastiness; Sweet – Ratings of Sweetness; Salt – Ratings of Saltiness; W – Weight of Food Consumed (gram.); D – Dinner Intake; E – Evening Intake; FD – Intake Following Dinner; EoD – End of Day Intake.

Figure 14.3: Correlation Matrix for Correlations between All Potential Influences on Appetite and All Behavioural Measures of Appetite continued (N=96) (significant correlations in bold)

	Gender	ConsS	ConsE	Preload	B.M.I.	Res	Pleas	Taste	Sweet	Salt
C - D	**.3775**	**-.2062**	-.0846	.0156	-.1012	.1374	.0727	**.2657**	-.0400	-.0397
	P< .001	**P= .044**	P= .412	P= .880	P= .327	P= .182	P= .481	**P=.009**	P= .699	P= .701
C - E	.1537	-.0250	.2013	.0015	-.1039	-.0236	.0001	.0528	-.0551	**.2036**
	P= .135	P= .809	P= .049	P= .988	P= .314	P= .820	P= .999	P=.609	P=.594	**P= .047**
C - FD	**.2918**	-.1503	-.0013	**-.4612**	-.0956	.1404	.0911	.1571	**.4096**	-.0558
	P= .004	P= .144	P= .990	**P< .001**	P= .354	P= .172	P= .378	P=.126	**P=.000**	P= .589
C - EoD	**.2389**	-.0784	.1281	**-.3958**	-.0822	.0535	.0796	.1199	**.3196**	.1032
	P= .019	P= .448	P= .214	**P< .001**	P= .426	P= .605	P= .441	P=.245	**P=.002**	P= .317
F - D	**-.5344**	.0833	-.0378	-.0123	.0773	**-.2044**	-.0259	-.1549	.0312	-.1617
	P< .001	P= .420	P= .715	P= .905	P= .454	**P= .046**	P= .802	P=.132	P=.763	P= .116
F - E	.0460	-.0186	-.0208	.0198	-.0119	-.1404	-.0281	**.2490**	.0276	.0551
	P= .656	P= .858	P= .841	P= .848	P= .908	P= .172	P= .786	**P=.014**	P=.790	P= .594
F - FD	**-.4186**	.0829	-.0986	.1172	.0743	**-.2174**	-.0097	-.1060	-.0832	-.1214
	P< .001	P= .422	P= .339	P= .255	P= .472	**P= .033**	P= .925	P= .304	P= .420	P= 239
F - EoD	-.1419	.0424	-.0452	.0955	.0343	**-.2026**	-.0160	.1715	-.0304	.0068
	P= .168	P= .682	P= .662	P= .355	P= .740	**P= .048**	P= .877	P= .095	P= .769	P= 947
P - D	.0703	.2460	**.2173**	-.0051	.0529	.0016	-.0658	**-.2343**	.0194	**.3230**
	P= .496	P= .016	**P= .033**	P= .961	P= .609	P= .988	P= .524	**P= .022**	P= .851	**P= .001**
P - E	.0095	-.1478	-.1584	.0856	.1058	-.0113	-.0586	.0122	-.1111	-.0055
	P= .927	P= .151	P= .123	P= .407	P= .305	P= .913	P= .570	P= .906	P= .281	P= .957
P - FD	.0332	.1852	.1894	**.5673**	.0513	.0022	-.1391	-.1404	**-.5220**	**.2991**
	P= .748	P= .071	P= .065	**P< .001**	P= .620	P= .983	P= .177	P= .173	**P< .001**	**P= .003**
P - EoD	.0010	.0525	-.0113	**.7132**	.0933	-.0003	**-.2286**	-.0905	**-.6713**	**.2090**
	P= .992	P= .611	P= .913	**P< .001**	P= .366	P= .998	**P= .025**	P= .380	**P< .001**	**P= .041**

Key: Gender – Gender; ConsS – Consumer-Sweet; ConsE – Consumer-Energy; Preload – Preload; B.M.I. – B.M.I.; Res – Restriant; Pleas – Ratings of Pleasantness; Taste – Ratings of Tastiness; Sweet – Ratings of Sweetness; Salt – Ratings of Saltiness; E – Energy Consumed (kcal.); C – Proportion of Energy consumed from Carbohydrate (%kcal.); F – Proportion of Energy consumed from Fat (%kcal.); P – Proportion of Energy consumed from Protein (%kcal.); D – Dinner Intake; E – Evening Intake; FD – Intake Following Dinner; EoD –End of Day Intake.

Test Meal Intake - Weight of Food Consumed (gram.):

On initial analysis, significant differences were found between genders and between preloads. A higher weight of food was consumed by male participants and following a sweet lunch.

On reanalysis, significant correlations were found between weight of food consumed at dinner and cumulatively throughout the day and B.M.I. (smallest r=0.2945, p=0.004), and weight consumed measured individually and cumulatively throughout the day and gender (smallest r=-0.289, p=0.004) and restraint (smallest r=0.2258, p=0.03). A greater weight of food consumed was associated with being male, a greater B.M.I. and a lower restraint.

On entering all variables into a multiple regression, significant regression equations were found for weight of food consumed - all measures (**Dinner - R^2= 0.418, adj R^2= 0.372, F(7,88)=9.03, p<0.0001; Evening - R^2= 0.181, adj R^2= 0.116, F(7,88)=2.77, p=0.01; Following Dinner - R^2= 0.503, adj R^2= 0.464, F(7,88)=12.75, p<0.0001; At the End of the Day - R^2= 0.428, adj R^2= 0.383, F(7,88)=9.42, p<0.0001)**. Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of weight of food consumed were gender (smallest Beta(88)=-0.273, p=0.01), B.M.I. (smallest Beta(88)=0.267, p=0.003) and restraint (smallest Beta(88)=-0.261, p=0.02) (see Table 14.6). A greater weight of food consumed was predicted by being male, being of a greater B.M.I. and a lower dietary restraint. Similar regressors were found for all analyses, although did not reach statistical significance in evening intake (see Appendix 14.2). These findings suggest that effects found in the previous analysis, of gender and preload are in fact effects of gender, B.M.I. and restraint. Effects of weight of food consumed thus were a result of individual differences as well as experimental variables.

Table 14.6: Results of Regression Equation for Weight of Food Consumed (gram.) - Following Dinner

Regressor	Beta	significance
Gender	**-0.428**	**<0.0001**
Consumer-sweet	-0.046	0.64
Consumer-energy	0.024	0.81
Preload	-0.035	0.64
B.M.I.	**0.276**	**0.001**
Restraint	**-0.277**	**0.008**
Tastiness	0.096	0.24

Test Meal Intake - Energy Consumed (kcal.):

On initial analysis, no effects were found in energy intake.

On reanalysis, significant correlations were found between energy consumed at dinner and cumulatively throughout the day and B.M.I. (smallest r=0.2850, p=0.005) and energy consumed measured individually and cumulatively throughout the day and gender (smallest r=-.2632, p=0.01) and restraint (smallest r=-0.2458, p=0.02). A greater energy consumed was associated with being male, a greater B.M.I. and a lower restraint.

On entering all variables into a multiple regression, significant regression equations were found for energy consumed at dinner and cumulatively throughout the day (**Dinner - R^2= 0.329, adj R^2= 0.276, F(7,88)=6.16, p<0.0001**; Evening - R^2= 0.142, adj R^2= 0.074, F(7,88)=2.09, p=0.06; **Following Dinner - R^2= 0.480, adj R^2= 0.438, F(7,88)=11.59, p<0.0001; At the End of the Day - R^2= 0.350, adj R^2= 0.299, F(7,88)=6.78, p<0.0001**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of energy consumed were gender (smallest Beta(88)=-0.226, p=0.05), B.M.I. (smallest Beta(88)=0.274, p=0.005), and restraint (Beta(88)=-0.239, p=0.02) (see Table 14.7). A greater energy consumed was predicted by being male, by a greater B.M.I. and a lower restraint. Similar regressors were found for all analyses, although restraint did not reach statistical significance in dinner intake or at the end of the day (see Appendix 14.2). These findings suggest all effects found in energy intake are a result of effects of experimental manipulation - gender, and individual differences - B.M.I. and restraint. In previous analyses however, no effects were statistically significant.

Table 14.7: Results of Regression Equation for Energy Consumed (kcal.) - Following Dinner

Regressor	Beta	significance
Gender	**-0.428**	**<0.0001**
Consumer-sweet	-0.077	0.45
Consumer-energy	-0.026	0.80
Preload	-0.033	0.67
B.M.I.	**0.299**	**0.0006**
Restraint	**-0.239**	**0.02**
Tastiness	0.090	0.28

Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.):

Carbohydrate:

On initial analysis, significant differences were found in proportion of energy consumed from carbohydrate between genders and between preload. A higher proportion of energy was consumed from carbohydrate by females and following a sweet lunch.

On reanalysis, significant correlations were found between proportion of energy consumed from carbohydrate at dinner and consumer-sweet (r=-0.2062, p=0.04) and ratings of tastiness (r=0.2657, p=0.01), carbohydrate consumed in the evening and ratings of saltiness (r=0.204, p=0.05), carbohydrate consumed cumulatively throughout the day and preload (smallest r=-0.3958, p<0.001) and ratings of sweetness (smallest r=0.3196, p=0.002), and carbohydrate consumed at dinner and cumulatively throughout the day and gender (smallest r=0.2389, p=0.02). A greater proportion of energy consumed from carbohydrate was associated with being female, with being a low consumer of sweetened beverages, with consuming a sweet lunch, higher ratings of tastiness, higher ratings of sweetness and higher ratings of saltiness.

Entering all variables into a multiple regression, significant regression equations were found for proportion of energy consumed from carbohydrate measured at dinner and cumulatively throughout the day (**Dinner - R^2= 0.222, adj R^2= 0.160, F(7,88)=3.59, p=0.002;** Evening - R^2= 0.087, adj R^2= 0.014, F(7,88)=1.20, p=0.31; **Following Dinner - R^2= 0.344, adj R^2= 0.292, F(7,88)=6.59, p<0.0001; At the End of the Day - R^2= 0.262, adj R^2= 0.203, F(7,88)=4.46, p=0.0003**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of proportion of energy consumed from carbohydrate in dinner intake were gender (Beta(88)=0.367, p=0.003) and ratings of taste (Beta(88)=0.200, p=0.05); following dinner were gender (Beta(88)=0.227, p=0.04) and preload (Beta(88)=-0.467, p<0.0001), and at the end of the day were preload (Beta(88)=-0.399, p<0.0001) (see Tables 14.8 - 14.10). A greater proportion of energy consumed from carbohydrate was predicted by being female, consuming a sweet lunch and higher ratings of tastiness. These findings suggest the effects of gender and preload found in the previous analysis are a combination of effects of gender, preload and ratings of tastiness. Effects in proportion of energy consumed from carbohydrate thus are a result of experimental manipulations and individual differences.

Table 14.8: Results of Regression Equation for Proportion of Energy Consumed from Carbohydrate (%kcal.) - Dinner Intake

Regressor	Beta	significance
Gender	**0.367**	**0.003**
Consumer-sweet	-0.144	0.25
Consumer-energy	-0.031	0.80
Preload	0.007	0.94
B.M.I.	-0.003	0.97
Restraint	-0.018	0.88
Tastiness	**0.200**	**0.05**

Table 14.9: Results of Regression Equation for Proportion of Energy Consumed from Carbohydrate (%kcal.) - Following Dinner

Regressor	Beta	significance
Gender	**0.227**	**0.04**
Consumer-sweet	-0.183	0.11
Consumer-energy	0.109	0.34
Preload	**-0.467**	**<0.0001**
B.M.I.	-0.028	0.76
Restraint	0.095	0.42
Tastiness	0.122	0.19
Sweetness	-0.177	0.51

Table 14.10: Results of Regression Equation for Proportion of Energy Consumed from Carbohydrate (%kcal.) - At the End of the Day

Regressor	Beta	significance
Gender	0.209	0.08
Consumer-sweet	-0.176	0.15
Consumer-energy	0.223	0.07
Preload	**-0.399**	**<0.0001**
B.M.I.	-0.015	0.88
Restraint	0.040	0.75
Tastiness	0.070	0.48
Sweetness	-0.464	0.10

Fat:

On initial analysis, significant differences were found in proportion of energy consumed from fat between genders. A greater proportion of energy from fat was consumed by males.

On reanalysis, significant correlations were found for proportion of energy consumed from fat at dinner and following dinner and gender (smallest $r=0.4186$, $p<0.001$), fat consumed at dinner and cumulatively throughout the day and restraint (smallest $r=-0.2026$, $p=0.05$) and fat consumed in the evening and ratings of taste ($r=0.2490$, $p=0.01$). A greater proportion of energy consumed from fat was associated with being male, with a lower restraint and with higher ratings of tastiness.

Entering all variables into a multiple regression, significant regression equations were found for proportion of energy consumed from fat measured at dinner and following dinner (**Dinner - R^2= 0.310, adj R^2= 0.255, F(7,88)=5.64, p<0.0001;** Evening - R^2= 0.109, adj R^2= 0.038, F(7,88)=1.54, p=0.16; **Following Dinner - R^2= 0.234, adj R^2= 0.173, F(7,88)=3.84, p=0.001;** At the End of the Day - R^2= 0.125, adj R^2= 0.055, F(7,88)=1.80, p=0.10). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, the significant predictor of proportion of energy consumed from fat was gender (smallest Beta(88)=-0.353, p=0.004) (see Tables 14.11 - 14.12). A greater proportion of energy consumed from fat was predicted by being male. These findings mirror those found previously. Effects of proportion of energy consumed from fat were not a result of any of the individual differences in this study.

Table 14.11: Results of Regression Equation for Proportion of Energy Consumed from Fat (%kcal.) - Dinner Intake

Regressor	Beta	significance
Gender	**-0.565**	**<0.0001**
Consumer-sweet	0.116	0.32
Consumer-energy	-0.076	0.52
Preload	-0.010	0.91
B.M.I.	-0.060	0.54
Restraint	0.048	0.69
Tastiness	-0.063	0.51

Table 14.12: Results of Regression Equation for Proportion of Energy Consumed from Fat (%kcal.) - Following Dinner

Regressor	Beta	significance
Gender	**-0.353**	**0.004**
Consumer-sweet	0.220	0.08
Consumer-energy	-0.243	0.05
Preload	0.118	0.21
B.M.I.	-0.023	0.82
Restraint	-0.133	0.30
Tastiness	-0.028	0.78

Protein:

On initial analysis, significant differences were found in proportion of energy consumed from protein, between preloads. A greater proportion of energy was consumed from protein following the non-sweet lunch.

On reanalysis, significant correlations were found between proportion of energy consumed from protein at dinner and consumer-energy ($r=0.2173$, $p=0.03$), ratings of tastiness ($r=-0.2343$, $p=0.02$) and ratings of saltiness ($r=0.323$, $p=0.001$), protein consumed cumulatively throughout the day and preload (smallest $r=0.5673$, $p<0.001$), ratings of pleasantness ($r=-0.229$, $p=0.03$), ratings of sweetness (smallest $r=-0.5220$, $p<0.001$) and ratings of saltiness ($r=0.209$, $p=0.04$). A greater proportion of energy consumed from protein was associated with being a high consumer of high energy beverages, consuming a non-sweet lunch, lower ratings of pleasantness, lower ratings of tastiness, lower ratings of sweetness and higher ratings of saltiness.

On entering all variables into a multiple regression, significant equations were found for proportion of energy consumed from protein measured cumulatively throughout the day (Dinner - $R^2= 0.133$, adj $R^2= 0.064$, $F(7,88)=1.93$, $p=0.07$; Evening - $R^2= 0.066$, adj $R^2= -0.009$, $F(7,88)=0.88$, $p=0.52$; **Following Dinner - $R^2= 0.398$, adj $R^2= 0.351$, $F(7,88)=8.32$, $p<0.0001$; At the End of the Day - $R^2= 0.539$, adj $R^2= 0.502$, $F(7,88)=14.69$, $p<0.0001$**). Using regressors of gender, consumer type, preload, B.M.I., dietary restraint and ratings of tastiness, significant predictors of proportion of energy consumed from protein, following dinner were preload ($Beta(88)=0.575$, $p<0.0001$) and ratings of tastiness ($Beta(88)=-0.179$, $p=0.05$), and at the end of the day were preload ($Beta(88)=0.719$, $p<0.0001$) (see Tables 14.13 - 14.14). A greater proportion of energy consumed from protein was predicted by consuming a non-sweet lunch and lower ratings of tastiness. These findings suggest that the effects of preload found previously are effects of preload and effects of ratings of tastiness. Effects in proportion of energy consumed from protein were a result of experimental manipulations and individual differences.

Table 14.13: Results of Regression Equation for Proportion of Energy Consumed from Protein (%kcal.) - Following Dinner

Regressor	Beta	significance
Gender	0.073	0.49
Consumer-sweet	0.051	0.64
Consumer-energy	0.169	0.12
Preload	**0.575**	**<0.0001**
B.M.I.	0.061	0.50
Restraint	-0.021	0.85
Tastiness	**-0.179**	**0.05**
Sweetness	0.167	0.52

Table 14.14: Results of Regression Equation for Proportion of Energy Consumed from Protein (%kcal.) - At the End of the Day

Regressor	Beta	significance
Gender	0.082	0.38
Consumer-sweet	0.026	0.78
Consumer-energy	-0.042	0.66
Preload	**0.719**	**<0.0001**
B.M.I.	0.122	0.13
Restraint	-0.086	0.38
Tastiness	-0.138	0.08
Sweetness	0.059	0.79

Summary:

All effects found in the original and re-analysis of Study 5 are summarized in Table 14.15.

Table 14.15: Summary of All Effects Found in the Original Analysis and Reanalysis of Study 5

	Effects in the Original Analysis	Effects in the Reanalysis
SM Hunger	Gender	Gender
SM Thirst	Consumer, Preload	Consumer
SM Appetite for Something Sweet	Consumer, Preload	Consumer, Preload
SM Appetite for Something Savoury	Preload	Preload, Tastiness
SM Appetite for a Meal	Preload	-----
BM Weight consumed	Gender, Preload	Gender, B.M.I., Restraint
BM Energy consumed	-----	Gender, B.M.I., Restraint
BM CHO consumed	Gender, Preload	Gender, Preload, Tastiness
BM Fat consumed	Gender	Gender
BM Protein consumed	Preload	Preload, Tastiness

14.2.3. DISCUSSION

All effects found in the original and re-analysis of Study 5 are summarized in Figure 14.4. The similarity of the findings resulting from the two differing methods of analysis are unsurprising and reassuring.

With the exception of effects of preload, as found in the subjective measures of thirst, subjective measures of appetite for a meal and weight of food consumed. all effects found in the original analysis were also found in the reanalysis of the data. Additional effects however, were also found in the reanalysis. In weight of food consumed and energy consumed, effects of B.M.I. and restraint were found. In subjective measures of appetite for something savoury and in proportion of energy consumed from carbohydrate and protein, effects of ratings of tastiness were found. These findings suggest that the effects found in weight of food consumed, energy consumed, subjective measures of appetite for something savoury and proportion of energy consumed from carbohydrate and protein were effects not only of the experimental manipulations of the study but were also effects of some of the differences between individuals. The absence of effects of preload in the reanalysis suggest these effects in the original analysis to be effects predominantly not of preload, but of differing responses to the differing preloads by differing genders or differing consumers. Many interactions between preload and gender, and preload and consumer were found in the original analysis.

14.2.3.1. Summary

This reanalysis thus suggests that the effects found in this study were influenced by experimental manipulations and individual differences. Effects of individual differences however, are small in comparison to the effects of the experimental manipulations. Few individual differences though were measured in the study: others may have more effect. The individual differences included in the reanalysis however, are those most reported to have most effect in appetite and appetite control.

14.3. INDIVIDUAL DIFFERENCES

The importance of individual differences on appetite and appetite control should not be underestimated. The number of potential influences on appetite which may differ between individuals are enormous. Many effects found in investigating appetite in groups of participants, may in actual fact be effects due to individual differences between participants within those groups (i.e. failure to ensure the same spread of individual differences in each of the experimental conditions). Some effects in this thesis may be attributable to individual differences. Throughout this thesis, however, those individual differences of greatest influence in appetite were taken into consideration in many of the original analyses. It is unlikely that alternatives could be found for all findings and explanations in this thesis in terms of individual differences. The present reanalysis demonstrates that many of the effects reported in this thesis are <u>not</u> attributable to some of the more plausible individual difference variables which could offer alternative explanations.

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APPENDICES

APPENDIX 6.1: Recipes for All Preload Drinks used in Studies 1, 3, and 4.

Sweetness / Energy Manipulation: NON-SWEET / LOW ENERGY — 0 kcal./g.
Drink: WATER (W) — 0 kcal./330 ml.
Recipe (/kg): 1000g Highland Spring Still Natural Mineral Water

Sweetness / Energy Manipulation: SWEET / LOW ENERGY — 0.02 kcal./g.
Drink: ARTIFICIALLY-SWEETENED DRINK (AS) — 5 kcal./330 ml.
Recipe (/kg): 100g No Added Sugar Ribena Blackcurrant Juice Drink (SmithKline Beecham)
900g Highland Spring Still Natural Mineral Water
Sweeteners: Aspartame, Acesulfame-K, (Fructose)

Sweetness / Energy Manipulation: SWEET / HIGH ENERGY — 0.4 kcal./g.
Drink: NATURALLY SWEETENED DRINK (NS) — 125 kcal./330 ml.
Recipe (/kg): 175g Ribena Blackcurrant Juice Drink (SmithKline Beecham)
825g Highland Spring Still Natural Mineral Water
Sweeteners: Sucrose, Glucose Syrup, (Fructose)

APPENDIX 6.2: Energy and Macronutrient Content of all Foods used in Study 1.

Foods	Energy (kcal/g)	Carbohydrate (g/g)	Fat (g/g)	Protein (g/g)
Tuna Mayonnaise and Lettuce Sandwiches (White)	2.749	0.284	0.028	0.108
Tuna Mayonnaise and Lettuce Sandwiches (Brown)	2.533	0.21	0.03	0.122
Coleslaw	0.598	0.065	0.031	0.017
Cheese and Tomato Pizza	2.33	0.33	0.073	0.089
Breadsticks	4.01	0.725	0.065	0.13
Popcorn *	4.09	0.81	0.083	0.027
Jelly Babies *	3.36	0.784	0	0.052
Marshmallows *	3.32	0.805	0	0.034
Strawberry Yoghurt	0.91	0.142	0.017	0.047
Water	0	0	0	0

* Only two items of confectionery were given to each participant, depending on preference.

Tuna Mayonnaise and Lettuce Sandwiches Recipe (/130g):
70g bread, 33g tinned tuna in brine, 7g reduced calorie mayonnaise, 20g lettuce
Coleslaw Recipe (/212.5g):
100g cabbage, 62.5g carrots, 20g reduced calorie mayonnaise, 30g natural yoghurt

APPENDIX 6.3: Results of All Covariate Tests in All ANCOVA Analyses - Subjective Measures - Study 1

Analyses	All Participants	
Covariates	Weight of Preload Consumed	
	Test t	Significance p
Hunger	**2.84**	**0.01**
Desire to Eat	**2.97**	**0.01**
Fullness	-0.20	0.84
Prospective Consumption	1.42	0.18
Thirst	**3.41**	**0.004**

APPENDIX 6.4: Results of All Covariate Tests in All ANCOVA Analyses - Behavioural Measures - Study 1

Analyses	All Participants	
Covariates	Weight of Preload Consumed	
	Test t	Significance p
Weight of Food Consumed (gram.)	-0.40	0.69
Energy Consumed (kcal.)	-0.30	0.77
Total Energy Consumed (kcal.)	0.50	0.63
Energy consumed from CHO (%kcal.)	-1.84	0.09
Energy consumed from Fat (%kcal.)	0.94	0.36
Energy consumed from Protein (%kcal.)	0.98	0.34
Time Delay before Consumption (min.)	-1.49	0.16

APPENDIX 7.1: Questionnaire used in Study 2.

SWEETNESS IN FOOD AND DRINK

The Nutrition Research Group at the University of Leeds is currently looking into Sweetness in Food and Drink. This questionnaire aims to discover the amounts and sources of sweetness in the diet, by looking at the amount of certain foods and drinks currently being consumed.
Please answer all questions as accurately and truthfully as possible. All answers will be kept anonymous and completely confidential. Thank-you for your time and co-operation.

Q1. Please consider each of the following foods, and mark down the quantity (ie. number of portions as defined in the brackets) of each you consume, at present. Those you don't consume please leave blank.

	5+ per day	2-4 per day	1 per day	2/3 per week	1 per week	rarely
Tabletop sugar (eg. in tea, coffee, etc.)(tspns)	☐	☐	☐	☐	☐	☐
Tabletop artificial sweetener (tspns/tablets)	☐	☐	☐	☐	☐	☐
Fruit (which) ....(items)	☐	☐	☐	☐	☐	☐
Yoghurts / Desserts (pots)	☐	☐	☐	☐	☐	☐
'Sugar-free' Yoghurt / Desserts (pots)	☐	☐	☐	☐	☐	☐
Biscuits, cakes and sweets (items)	☐	☐	☐	☐	☐	☐
'Sugar free' sweets (packets)	☐	☐	☐	☐	☐	☐
'Sugar free' chewing gum (pieces)	☐	☐	☐	☐	☐	☐
Regular squash (glasses)	☐	☐	☐	☐	☐	☐
'Low/reduced sugar ' squash (glasses)	☐	☐	☐	☐	☐	☐
Carbonated drinks (cans)	☐	☐	☐	☐	☐	☐
'Diet' carbonated drinks (cans)	☐	☐	☐	☐	☐	☐
Bottled water (glasses)	☐	☐	☐	☐	☐	☐

Q2. Do you think about the sources of sweetness in your diet ? Yes / No

Q3. Do you ever eat artificial sweeteners / 'diet' products in preference to sugar / regular products? Yes / No

Q4. Why do you think people consume sugar ? Please rate the following reasons on their importance on a scale of 1 to 5 where 1 is very important and 5 is not at all important

taste	1	2	3	4	5
health	1	2	3	4	5
energy	1	2	3	4	5
alertness	1	2	3	4	5
performance	1	2	3	4	5
other	1	2	3	4	5

Q5. Why do you think people consume artificial sweeteners ? Please rate the following reasons on their importance on a scale of 1 to 5 where 1 is very important and 5 is not at all important

taste	1	2	3	4	5
health	1	2	3	4	5
to reduce sugar intake	1	2	3	4	5
to reduce calorific intake	1	2	3	4	5
to aid weight loss	1	2	3	4	5
other	1	2	3	4	5

Q6. Are you currently dieting ? Yes / No

Q7. Age ? .... Sex ? .... Occupation ? ....

Q8. Approx. Height ? .... Approx. Weight ? ....

Q9. Thank you very much for your response and if you would be willing to help further with this research please leave your initials ---------------- and a contact address or phone number --------------------------------

(this is not market research and you will not receive any junk mail)

Thank-you again for your time and co-operation in completing this questionnaire. As previously stated all answers and comments will be kept anonymous and completely confidential. Please return all completed copies to the box provided or to K. Appleton, Dept. of Psychology, University of Leeds, Leeds, LS2 9JT

APPENDIX 7.2: All Manufacturers and Products used in Calculation of Mean Artificial Sweetener Concentration (mg) per Product Type.

Product Type	**'Diet' Squash**	
Brand	Product	
Boots	Shapers Blackcurrant Drink 1L	Shapers Orange Barley 1L
	Shapers Lemon Barley 1L	
Co-op	Vit C Light Blackcurrant Cordial	L/C Orange Drink
	Sugar Free Apple and Blackberry	Sugar Free Strawberry
	Sugar Free Lemon	Sugar Free Mixed Fruit
	Sugar Free Orange	Sugar Free Orange and Pineapple
	Sugar Free Apple	
Product Type	**'Diet' Carbonated Drinks**	
Brand	Product	
AG Barr	Diet Irn Bru	Diet Lemonade
	Diet Dandelion and Burdock	Diet Tizer
	Barr Diet Cola	
Boots	Shapers Red Grapefruit Crush	Shapers Blackcurrant and Apple
	Shapers Orange Crush	Shapers Cloudy Lemonade
	Shapers Lemon and Lime Crush	Shapers Citrus Fruit
	Shapers Forest Fruit Crush	Shapers Tropical Fruit
Britvic	Tango - Low Calorie Blackcurrant	Tango - Low Calorie Lemon
	Tango - Low Calorie Apple	Tango - Low Calorie Orange
	Pepsi Max	Diet Pepsi
Coca-Cola	Diet Coke	Diet Lilt
Co-op	L/C Lemonade	Diet Lemonade (can)
	L/C Orangeade	Diet Cola Decaff (can)
	Diet Cola	Diet Orangeade (can)
	Traditional Diet Lemonade	L/C American Dry Ginger
	Diet Pink Lemonade	L/C Bitter Lemon
	Diet Blue Lemonade	L/C Indian Tonic Water
Product Type	**'Sugar-Free' Gum**	
Brand	Product	
Wrigley	Extra	Orbit
Product Type	**'Sugar-Free' Sweets**	
Brand	Product	
Boots	Shapers mini Milk Choc Bars (5)	Shapers Chunky Praline
	Shapers mini Hazelnut Choc Bars (5)	Light Mild Mints
	Shapers mini Coconut Choc Bars (5)	Lemon Sweets
	Shapers Turkish Delight	
Product Type	**'Sugar-Free' Yoghurts / Desserts**	
Brand	Product	
Ambrosia	Low Fat Rice Pudding	Low Fat Devon Custard
Boots	Shapers Mandarin Delight	Shapers Double Choc. Sundae
	Shapers Apple Crumble Dessert	Shapers Banana Sundae
	Shapers Rhubarb Crumble Dessert	Shapers Strawberry Sundae
	Shapers Chocolate Trifle	Shapers Blueberry Mousse
	Shapers Lemon Delight	Shapers Peach and Vanilla Yoghurt
	Shapers Greek Style and Vanilla	Shapers Apple Nut / Raisin Yoghurt
	Shapers Greek Style Raspberry	Shapers Strawberry Yoghurt
	Shapers Greek Style Strawberry	Shapers Lemon and Lime Yoghurt
Co-op	Very Low Fat Yoghurts	Bio-lite Very low Fat Yoghurts
	Very Low Fat Fromage Frais	Sugar Free Banana Supreme Delight
	Sugar Free Choc Supreme Delight	Sugar Free Str'b'y Supreme Delight

All Manufacturers and Products used in Calculation of Mean Artificial Sweetener Concentration (mg) per Product Type continued.

Product Type	**'Sugar-Free' Yoghurts / Desserts**	
Brand	Product	
Co-op	Low Sugar Instant Custard	Low Fat Rice Pudding
	Blackcherry Jelly	Pineapple Jelly
	Blackcurrant Jelly	Raspberry Jelly
	Lemon Jelly	Strawberry Jelly
	Lime Jelly	Tangerine Jelly
	Orange Jelly	
St. Ivel	Shape Fromage Frais	Shape Bio Yoghurt
	Shape Fromage Frais Twinpot	Shape Bio Extra Fruit Yoghurt
	Shape Temptations	Shape Bio Twinpot
	Cadburys Light Dessert	Cadburys Low Calorie Mousse
Product Type	**Table Top Artificial Sweeteners**	
Brand	Product	
Hermes	Hermesetas Original	Hermesetas Gold Choice
	Hermesetas Liquid	Hermesetas Granulated
Scholl	Natrena	
Searle	Canderel	Canderel Spoonful
Product Type	**Regular Squash**	
Brand	Product	
AG Barr	Jusoda Blackcurrant Cordial	Jusoda Lime Juice Cordial
	Jusoda Lemon Barley	Jusoda Orange Drink
Boots	Whole Lemon Drink 1L	Orange Barley Water 1L
	Whole Orange Drink 1L	Lemon Barley Water 1L
Co-op	Lemon Barley Water	Lime Cordial
	Orange Barley Water	Blackcurrant Cordial
Co-op Sun Up	Apple and Blackberry	Orange and Pineapple
	Apple Drink	Whole Lemon
	Mixed Fruit Drink	Whole Orange
Product Type	**Regular Carbonated Drinks**	
Brand	Product	
AG Barr	Prize Cherryade	Prize Lemonade
	Prize Cream Soda	Prize Lime and Lemonade
	Prize Cola	Prize Orangeade
	American Cream Soda	Jusoda Orange
	Dandelion and Burdock	Red Kola
	Ginger Beer	Irn Bru XS
	Lemonade	
Britvic	Tango - Blackcurrant	Tango - Orange
	Tango - Pineapple and Grapefruit	Tango - Lemon
Co-op	Traditional Dandelion and Burdock	Lemonade
	Traditional Cream Soda	Traditional Lemonade
	Orangade	Real Lemon Lemonade
	Cola	Pink Lemonade
	Ginger Beer	Blue Lemonade
	Raspberryade	Indian Tonic Water
	Limeade	Bitter Lemon
	Lemonade (can)	Cola (can)
	Orangade (can)	

APPENDIX 8.1: Drinks F.F.Q., used in recruitment for Studies 3, 4, 5, 6, and 8.

NUTRITION STUDY

The Nutrition Group at the University of Leeds is currently looking at the relationships between diet and various types of eating behaviours and eating patterns.

To participate in any of the related nutrition studies please complete the following questionnaire. Please answer all questions, and do so as accurately and truthfully as possible. All answers will be kept completely confidential.

Having completed the questionnaire, please return it: Katherine Appleton,
B.28, Department of Psychology, University of Leeds, Leeds, LS2 9JT. Thank you.

Personal Details

Name:.. Phone (work / home) / Email:.......................................

Sex: Male / Female Date of Birth:.................................. Age:.............................

Height:................................ Weight:.................................... (please be as exact as possible)

Are you a smoker? Yes / No
If yes: How many cigarettes do you smoke per day?......................

Are you a vegetarian? Yes / No Are you Currently Dieting? Yes / No

Diet Questionnaire
INSTRUCTIONS - Please consider each of the following foods, and mark down the quantity of each you consume, at present. Delete whether each is consumed on a daily or weekly rate.

Water - .... glasses per day / week

Regular squash - .... glasses per day / week

'Diet' squash - .... glasses per day / week

Regular carbonated drinks - .... cans per day / week

'Diet' carbonated drinks - .... cans per day / week

Coffee - .... cups per day / week, each with .... sugar
- .... cups per day / week, each with .... artificial sweetener

Tea - .... cups per day / week, each with .... sugar
- .... cups per day / week, each with .... artificial sweetener

Hot Chocolate - .... cups per day / week

Milk - .... glasses per day / week
Milkshake - .... glasses per day / week

Fruit Juice - .... glasses per day / week

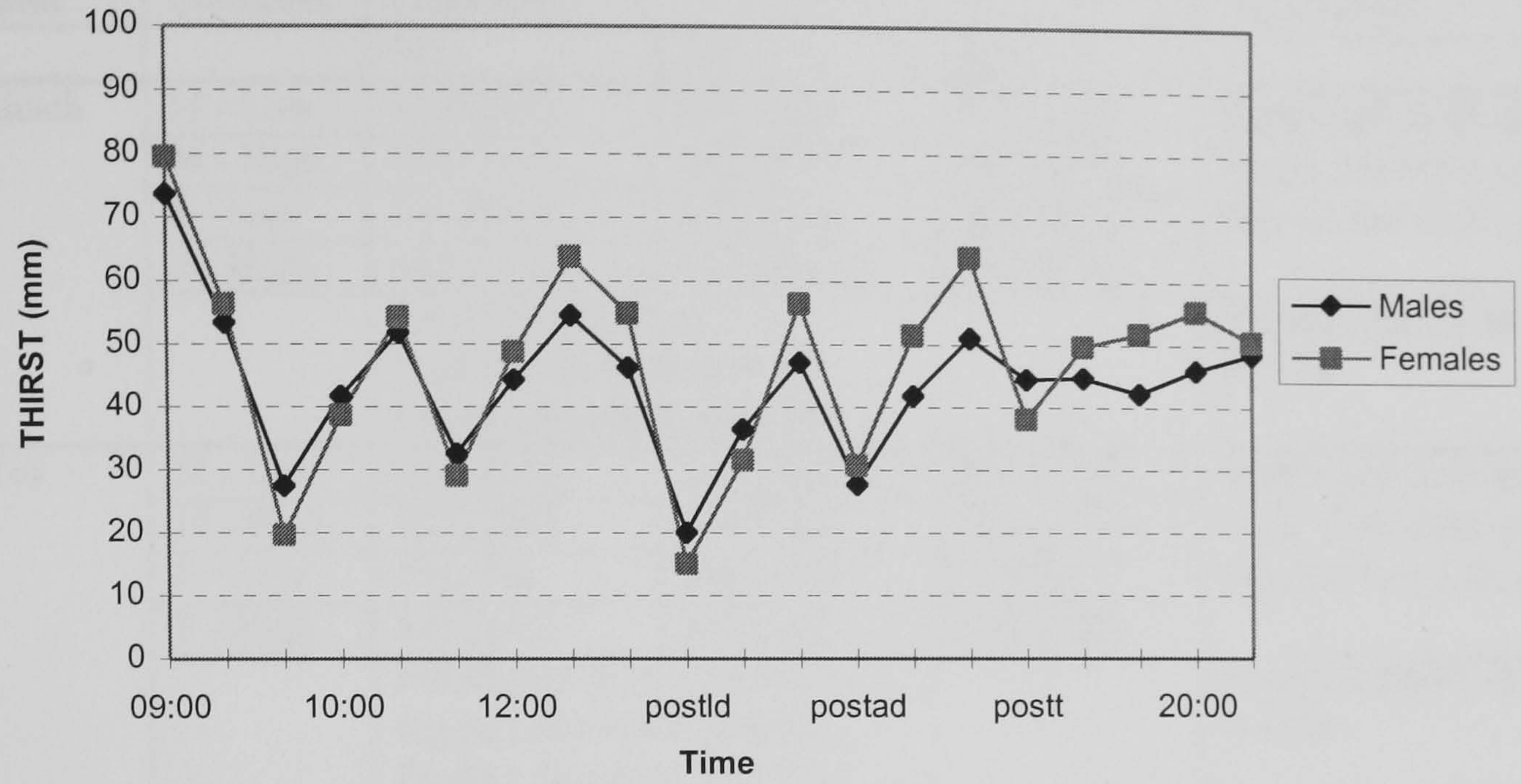
APPENDIX 8.2: Energy and Macronutrient Content of all Foods used in Study 3.

Foods - Lunch	Energy (kcal/g)	Carbohydrate (g/g)	Fat (g/g)	Protein (g/g)
Vegetable Lasagne	1.08	0.114	0.053	0.037
Peas *	0.62	0.090	0.007	0.049
Carrots *	0.30	0.060	0.005	0.007
Sweetcorn *	0.84	0.160	0.005	0.028
Chocolate Biscuits	5.06	0.657	0.240	0.068
Apples	0.45	0.115	0.001	0.003
Water	0	0	0	0
Foods - Tea	**Energy (kcal/g)**	**Carbohydrate (g/g)**	**Fat (g/g)**	**Protein (g/g)**
Cream Cheese Sandwiches **	2.05	0.288	0.057	0.094
Turkey Sandwiches **	2.00	0.260	0.053	0.120
Honey Roast Turkey Sandwiches **	2.02	0.256	0.052	0.130
Coleslaw	0.64	0.051	0.041	0.017
Cheese and Tomato Pizza	2.42	0.292	0.092	0.106
Jelly Babies ***	3.36	0.784	0	0.052
Marshmallows ***	3.32	0.805	0	0.034
Popcorn ***	4.09	0.810	0.083	0.027
Strawberry Yoghurt	0.91	0.142	0.017	0.047
Water	0	0	0	0
Foods - Snackbox	**Energy (kcal/g or kcal/ptn)**	**Carbohydrate (g/g or g/ptn)**	**Fat (g/g or g/ptn)**	**Protein (g/g or g/ptn)**
Bread Rolls (brown)	2.36	0.450	0.019	0.097
Bread Rolls (white)	2.48	0.470	0.028	0.088
Margarine (ptn)	63.5	0.10	7.00	0.02
Cheese (ptn)	82.4	0.02	6.88	5.10
Jam (ptn)	52.2	13.80	0	0.12
Crisps (ptn)	159.5	13.35	11.00	1.75
Biscuits (ptn)	155.0	20.10	7.30	2.00
Yoghurts (ptn)	85.8	14.58	0.12	3.66
Apples	0.45	0.115	0.001	0.003

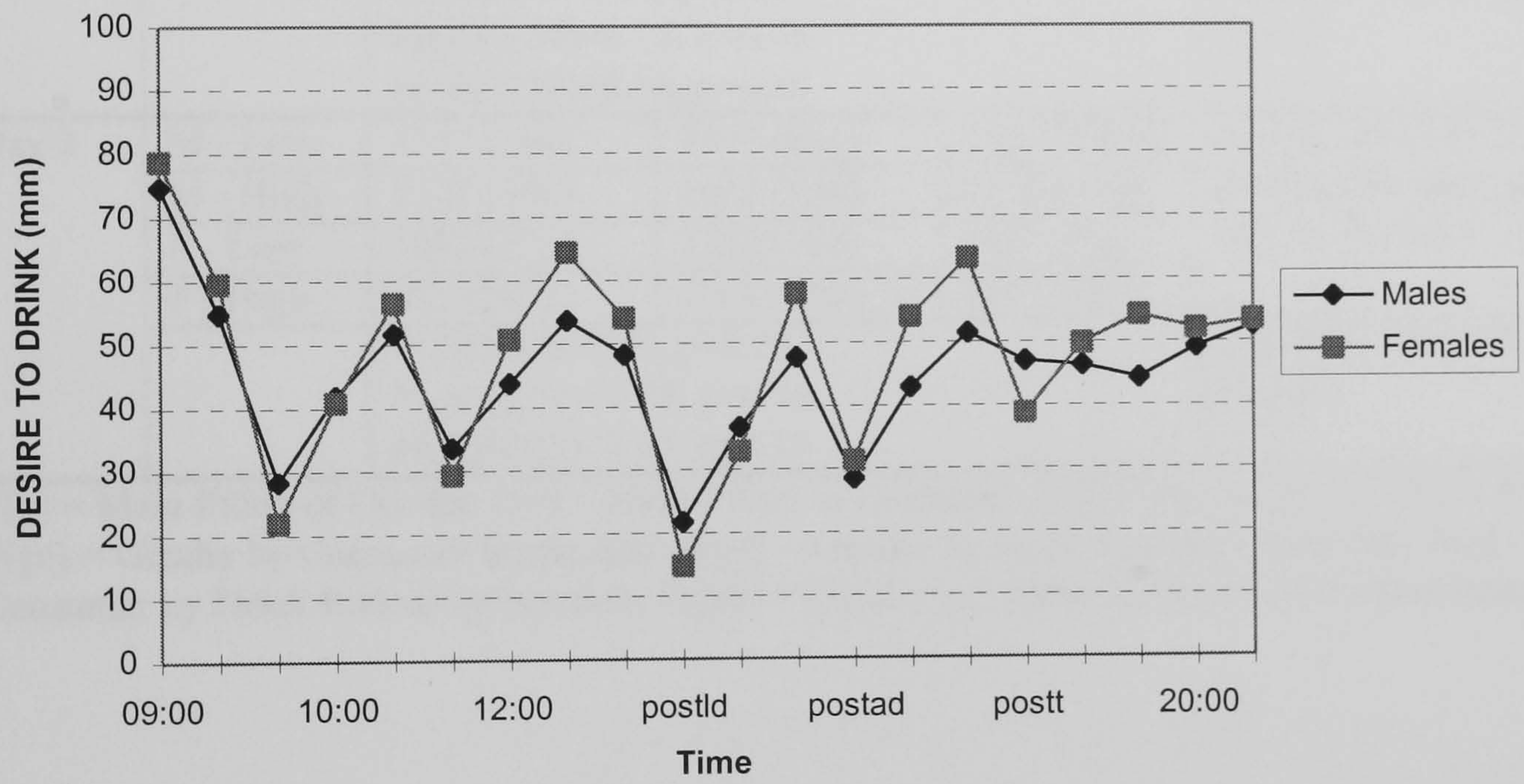
* only one vegetable item was given to each participant, depending on preference
** only one type of sandwich was given to each participant, depending on preference and availability
*** only two items of confectionery was given to each participant, depending on preference

Cream Cheese Sandwich Recipe (/95g):
    70g brown bread, 25g Philadelphia Light cream cheese
Turkey Sandwiches (/105g):
    70g brown bread, 30g turkey slices, 5g margarine
Honey Roast Turkey Sandwiches (/105g):
    70g brown bread, 30g honey roast turkey slices, 5g margarine

APPENDIX 8.3: Temporal Profile for Subjective Measures of THIRST - Gender by Time - Study 3



APPENDIX 8.4: Temporal Profile for Subjective Measures of DESIRE TO DRINK - Gender by Time - Study 3



APPENDIX 8.5: Individual Test Meal Intake - Weight Consumed (gram) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	973 (249)	984 (248)	936 (228)	**F(g)(1,26)=8.15, p=0.01** F(c)(1,26)=0.59, p=0.45 F(gc)(1,26)=0.37, p=0.55
	M - High	844 (197)	968 (260)	880 (250)	
	F - Low	730 (132)	626 (83.5)	623 (192)	
	F - High	646 (139)	807 (262)	780 (259)	
		F(d)(2,56)=1.70, p=0.19 F(gd)(2,56)=0.48, p=0.62 **F(cd)(2,56)=6.49, p=0.003**			F(gcd)(2,56)=1.36, p=0.26
Tea	M - Low	635 (216)	641 (317)	641 (158)	F(g)(1,26)=3.55, p=0.07 F(c)(1,26)=0.00, p=0.95 F(gc)(1,26)=1.32, p=0.26
	M - High	527 (239)	544 (259)	527 (273)	
	F - Low	371 (78)	368 (115)	373 (98)	
	F - High	441 (192)	460 (183)	479 (195)	
		F(d)(2,56)=0.17, p=0.85 F(gd)(2,56)=0.13, p=0.86 F(cd)(2,56)=0.08, p=0.92			F(gcd)(2,56)=0.13, p=0.88
Evening	M - Low	296 (234)	384 (203)	272 (173)	F(g)(1,25)=3.14, p=0.09 F(c)(1,25)=0.02, p=0.88 F(gc)(1,25)=0.00, p=0.99
	M - High	369 (297)	382 (246)	361 (336)	
	F - Low	175 (145)	170 (137)	146 (105)	
	F - High	275 (188)	242 (104)	242 (210)	
		F(d)(2,54)=0.90, p=0.41 F(gd)(2,54)=0.75, p=0.48 F(cd)(2,54)=0.56, p=0.58			F(gcd)(2,54)=0.17, p=0.85
Day 2	M - Low	1357 (366)	1467 (664)	1499 (492)	F(g)(1,24)=1.81. p=0.19 **F(c)(1,24)=5.03, p=0.03** F(gc)(1,24)=0.11, 0.74
	M - High	1122 (306)	1022 (536)	1319 (390)	
	F - Low	1093 (273)	1302 (562)	1197 (439)	
	F - High	952 (267)	1001 (330)	1011 (234)	
		F(d)(2,52)=1.28, p=0.29 F(gd)(2,52)=1.78, p=0.18 F(cd)(2,52)=1.93, p=0.16			F(gcd)(2,52)=0.50, p=0.61

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.6: Cumulative Test Meal Intake - Weight Consumed (gram) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	973 (249)	984 (248)	936 (228)	**F(g)(1,26)=8.15, p=0.01** F(c)(1,26)=0.59, p=0.45 F(gc)(1,26)=0.37, p=0.55
	M - High	844 (197)	968 (260)	880 (250)	
	F - Low	730 (132)	626 (83.5)	623 (192)	
	F - High	646 (139)	807 (262)	780 (259)	
		F(d)(2,56)=1.70, p=0.19 F(gd)(2,56)=0.48, p=0.62 **F(cd)(2,56)=6.49, p=0.003**			F(gcd)(2,56)=1.36, p=0.26
+ Tea	M - Low	1608 (381)	1625 (502)	1577 (361)	**F(g)(1,26)=8.33, p=0.01** F(c)(1,26)=0.26, p=0.62 F(gc)(1,26)=1.16, p=0.29
	M - High	1372 (299)	1512 (417)	1407 (379)	
	F - Low	1102 (130)	994 (137)	996 (190)	
	F - High	1087 (271)	1266 (367)	1259 (404)	
		F(d)(2,56)=1.32, p=0.28 F(gd)(2,56)=0.53, p=0.59 **F(cd)(2,56)=4.65, p=0.01**			F(gcd)(2,56)=1.17, p=0.32
+ Evening	M - Low	1906 (503)	2009 (545)	1849 (434)	**F(g)(1,25)=9.00, p=0.01** F(c)(1,25)=0.10, p=0.75 F(gc)(1,25)=0.69, p=0.42
	M - High	1741 (474)	1895 (571)	1768 (540)	
	F - Low	1277 (196)	1164 (135)	1142 (156)	
	F - High	1362 (454)	1508 (431)	1501 (568)	
		F(d)(2,54)=1.76, p=0.18 F(gd)(2,54)=1.11, p=0.34 F(cd)(2,54)=2.15, p=0.13			F(gcd)(2,54)=0.76, p=0.47
+ Day 2	M - Low	3263 (793)	3476 (1021)	3348 (715)	**F(g)(1,24)=7.48. p=0.01** F(c)(1,24)=2.75, p=0.11 F(gc)(1,24)=1.23, p=0.28
	M - High	2738 (466)	2917 (946)	3087 (646)	
	F - Low	2370 (398)	2466 (588)	2339 (424)	
	F - High	2314 (593)	2509 (583)	2511 (546)	
		F(d)(2,52)=1.00, p=0.37 F(gd)(2,52)=0.45, p=0.64 F(cd)(2,52)=1.47, p=0.24			F(gcd)(2,52)=0.89, p=0.42

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.7: Individual Test Meal Intake - Energy Consumed (kcal) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	1028 (304)	1037 (289)	972 (300)	**F(g)(1,26)=5.84, p=0.02** F(c)(1,26)=0.20, p=0.66 F(gc)(1,26)=0.46, p=0.51
	M - High	1001 (207)	1113 (305)	969 (310)	
	F - Low	740 (65)	648 (66)	684 (297)	
	F - High	727 (196)	976 (316)	923 (337)	
		F(d)(2,56)=1.52, p=0.23 F(gd)(2,56)=1.05, p=0.29 **F(cd)(2,56)=3.51, p=0.04**			F(gcd)(2,56)=1.28, p=0.29
Tea	M - Low	1067 (316)	989 (477)	1057 (255)	F(g)(1,26)=2.45, p=0.13 F(c)(1,26)=0.12, p=0.73 F(gc)(1,26)=1.27, p=0.27
	M - High	962 (487)	994 (516)	962 (508)	
	F - Low	622 (220)	601 (288)	612 (249)	
	F - High	811 (233)	832 (221)	875 (226)	
		F(d)(2,56)=0.21, p=0.82 F(gd)(2,56)=0.11, p=0.90 F(cd)(2,56)=0.59, p=0.56			F(gcd)(2,56)=0.45, p=0.64
Evening	M - Low	998 (522)	952 (559)	865 (489)	**F(g)(1,25)=4.59, p=0.04** F(c)(1,25)=0.02, p=0.89 F(gc)(1,25)=0.08, p=0.78
	M - High	1127 (476)	1136 (312)	1037 (426)	
	F - Low	613 (421)	675 (244)	628 (343)	
	F - High	897 (380)	885 (342)	817 (637)	
		F(d)(2,54)=0.74, p=0.48 F(gd)(2,54)=0.16, p=0.86 F(cd)(2,54)=0.02, p=0.98			F(gcd)(2,54)=0.16, p=0.86
Day 2	M - Low	2304 (606)	2314 (792)	2609 (447)	F(g)(1,24)=1.88, p=0.18 F(c)(1,24)=2.98, p=0.10 F(gc)(1,24)=0.01, 0.92
	M - High	2621 (490)	2268 (554)	3119 (1511)	
	F - Low	1746 (561)	1901 (438)	2121 (453)	
	F - High	1933 (588)	2008 (716)	1710 (858)	
		F(d)(2,52)=2.98, p=0.10 F(gd)(2,52)=2.33, p=0.11 F(cd)(2,52)=0.20, p=0.82			F(gcd)(2,52)=2.03, p=0.14

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.8: Cumulative Test Meal Intake - Energy Consumed (kcal) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Meals	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	1028 (304)	1037 (289)	972 (300)	**F(g)(1,26)=5.84, p=0.02**
	M - High	1001 (207)	1113 (305)	969 (310)	F(c)(1,26)=0.20, p=0.66
	F - Low	740 (65)	648 (66)	684 (297)	F(gc)(1,26)=0.46, p=0.51
	F - High	727 (196)	976 (316)	923 (337)	
		F(d)(2,56)=1.52, p=0.23			F(gcd)(2,56)=1.28, p=0.29
		F(gd)(2,56)=1.05, p=0.29			
		F(cd)(2,56)=3.51, p=0.04			
+ Tea	M - Low	2095 (527)	2026 (694)	2029 (527)	**F(g)(1,26)=5.08, p=0.03**
	M - High	1964 (558.9)	2107 (750)	1932 (649)	F(c)(1,26)=0.21, p=0.65
	F - Low	1362 (208)	1249 (317)	1295 (336)	F(gc)(1,26)=1.25, p=0.28
	F - High	1538 (300)	1808 (438)	1797 (505)	
		F(d)(2,56)=0.53, p=0.59			F(gcd)(2,56)=0.85, p=0.43
		F(gd)(2,56)=0.88, p=0.42			
		F(cd)(2,56)=3.51, p=0.04			
+ Evening	M - Low	3093 (752)	2978 (702)	2894 (789)	**F(g)(1,25)=8.03, p=0.01**
	M - High	3106 (838)	3243 (829)	2934 (905)	F(c)(1,25)=0.08, p=0.78
	F - Low	1975 (492)	1924 (336)	1923 (355)	F(gc)(1,25)=0.44, p=0.52
	F - High	2435 (637)	2692 (626)	2615 (1083)	
		F(d)(2,54)=0.83, p=0.44			F(gcd)(2,54)=0.17, p=0.84
		F(gd)(2,54)=1.01, p=0.37			
		F(cd)(2,54)=1.18, p=0.31			
+ Day 2	M - Low	5397 (1205)	5292 (1029)	5504 (833)	**F(g)(1,24)=9.00. p=0.01**
	M - High	5387 (679)	5511 (906)	5694 (1811)	F(c)(1,24)=0.30, p=0.59
	F - Low	3721 (749)	3824 (514)	4044 (748)	F(gc)(1,24)=0.99, p=0.33
	F - High	4368 (945)	4700 (387)	4326 (884)	
		F(d)(2,52)=0.48, p=0.62			F(gcd)(2,52)=0.60, p=0.55
		F(gd)(2,52)=0.60, p=0.55			
		F(cd)(2,52)=0.19, p=0.82			

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.9: Cumulative Total Energy Intake (kcal) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch + Morning Drinks	M - Low	1028 (304)	1047 (289)	1222 (300)	**F(g)(1,26)=5.84, p=0.02** F(c)(1,26)=0.20, p=0.66 F(gc)(1,26)=0.46, p=0.51
	M - High	1001 (207)	1123 (305)	1219 (311)	
	F - Low	740 (66)	658 (66)	934 (297)	
	F - High	727 (196)	986 (316)	1173 (337)	
		F(d)(2,56)=20.39, p<0.001 F(gd)(2,56)=1.05, p=0.36 **F(cd)(2,56)=3.51, p=0.04**			F(gcd)(2,56)=1.28, p=0.29
+ Tea + Afternoon Drinks	M - Low	2095 (527)	2046 (694)	2529 (527)	**F(g)(1,26)=5.08, p=0.03** F(c)(1,26)=0.21, p=0.65 F(gc)(1,26)=1.25, p=0.28
	M - High	1964 (559)	2127 (750)	2432 (649)	
	F - Low	1362 (208)	1269 (317)	1795 (336)	
	F - High	1538 (300)	1828 (438)	2298 (505)	
		F(d)(2,56)=49.99, p<0.001 F(gd)(2,56)=0.88, p=0.42 **F(cd)(2,56)=3.51, p=0.04**			F(gcd)(2,56)=0.85, p=0.43
+ Evening	M - Low	3092 (752)	2998 (702)	3394 (789)	**F(g)(1,25)=8.03, p=0.01** F(c)(1,25)=0.08, p=0.78 F(gc)(1,25)=0.44, p=0.52
	M - High	3106 (838)	3263 (829)	3434 (905)	
	F - Low	1975 (492)	1944 (336)	2423 (355)	
	F - High	2435 (637)	2712 (626)	3115 (1083)	
		F(d)(2,54)=14.11, p<0.001 F(gd)(2,54)=1.01, p=0.37 F(cd)(2,54)=1.18, p=0.31			F(gcd)(2,54)=0.17, p=0.84
+ Day 2	M - Low	5397 (1205)	5312 (1029)	6004 (833)	**F(g)(1,24)=9.00, p=0.01** F(c)(1,24)=0.30, p=0.59 F(gc)(1,24)=0.99, 0.33
	M - High	5387 (679)	5531 (906)	6194 (1811)	
	F - Low	3721 (749)	3844 (514)	4544 (748)	
	F - High	4368 (945)	4720 (387)	4826 (884)	
		F(d)(2,52)=8.44, p=0.001 F(gd)(2,52)=0.60, p=0.55 F(cd)(2,52)=0.19, p=0.82			F(gcd)(2,52)=0.60, p=0.55

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.10: Individual Test Meal Intake - Proportions of All Macronutrients consumed (%kcal) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Proportions of Carbohydrate Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	45.0 (2.1)	44.4 (1.6)	44.9 (1.3)	F(g)(1,26)=3.31, p=0.08
	M - High	44.7 (2.4)	45.5 (2.8)	44.8 (2.4)	F(c)(1,26)=0.65, p=0.43
	F - Low	45.2 (3.6)	45.7 (3.1)	44.7 (2.3)	F(gc)(1,26)=3.31, p=0.08
	F - High	44.8 (2.6)	44.2 (1.5)	44.1 (1.6)	
		F(d)(2,56)=0.92, p=0.40 F(gd)(2,56)=0.78, p=0.46 F(cd)(2,56)=0.05, p=0.95			**F(gcd)(2,56)=3.44, p=0.04**
Tea	M - Low	53.1 (4.1)	52.9 (2.4)	53.4 (3.2)	**F(g)(1,24)=5.70, p=0.03**
	M - High	57.1 (4.3)	56.2 (4.9)	56.6 (4.5)	F(c)(1,24)=0.57, p=0.46
	F - Low	58.3 (7.6)	58.4 (6.2)	58.6 (7.4)	F(gc)(1,24)=0.00, p=0.98
	F - High	57.9 (5.4)	59.7 (6.2)	59.2 (5.9)	
		F(d)(2,52)=0.24, p=0.79 F(gd)(2,52)=1.36, p=0.27 F(cd)(2,52)=0.38, p=0.69			F(gcd)(2,52)=0.28, p=0.76
Evening	M - Low	45.5 (7.6)	44.7 (9.4)	46.3 (10.0)	F(g)(1,22)=0.00, p=0.99
	M - High	43.3 (6.1)	42.6 (8.1)	43.1 (8.9)	F(c)(1,22)=0.08, p=0.78
	F - Low	48.8 (15.9)	45.9 (18.2)	35.0 (14.7)	F(gc)(1,22)=0.28, p=0.60
	F - High	44.7 (5.5)	45.3 (4.6)	45.7 (8.4)	
		F(d)(2,48)=0.87, p=0.42 F(gd)(2,48)=1.33, p=0.28 F(cd)(2,48)=1.26, p=0.29			F(gcd)(2,48)=1.64, p=0.21
Day 2	M - Low	50.7 (7.9)	50.3 (24.1)	56.0 (14.3)	F(g)(1,24)=1.46, p=0.24
	M - High	46.0 (9.0)	38.9 (6.7)	50.2 (18.2)	F(c)(1,24)=1.40, p=0.25
	F - Low	47.5 (8.3)	57.9 (23.0)	60.1 (21.7)	F(gc)(1,24)=0.33, p=0.57
	F - High	51.9 (12.4)	49.8 (18.0)	49.2 (26.8)	
		F(d)(2,54)=1.29, p=0.28 F(gd)(2,54)=0.88, p=0.42 F(cd)(2,54)=1.15, p=0.33			F(gcd)(2,54)=0.55, p=0.58

Proportions of Fat Consumed

FAT	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	38.6 (2.4)	39.3 (2.3)	38.4 (1.9)	**F(g)(1,26)=5.50, p=0.03**
	M - High	39.5 (3.1)	38.9 (2.8)	39.0 (2.7)	F(c)(1,26)=3.58, p=0.07
	F - Low	38.6 (4.3)	37.8 (4.0)	39.3 (2.2)	F(gc)(1,26)=4.03, p=0.06
	F - High	39.5 (2.8)	40.5 (1.5)	40.4 (2.2)	
		F(d)(2,56)=0.31, p=0.74 F(gd)(2,56)=2.09, p=0.13 F(cd)(2,56)=0.12, p=0.89			**F(gcd)(2,56)=3.20, p=0.05**
Tea	M - Low	26.4 (3.8)	26.2 (2.9)	25.9 (3.7)	F(g)(1,24)=3.87, p=0.06
	M - High	22.4 (3.6)	23.5 (4.0)	23.2 (3.5)	F(c)(1,24)=0.03, p=0.87
	F - Low	21.2 (6.4)	20.5 (4.7)	21.0 (6.0)	F(gc)(1,24)=0.55, p=0.46
	F - High	23.0 (4.6)	21.5 (5.2)	22.0 (4.5)	
		F(d)(2,52)=0.08, p=0.92 F(gd)(2,52)=1.88, p=0.16 F(cd)(2,52)=0.12, p=0.89			F(gcd)(2,52)=0.45, p=0.64

Proportions of Fat Consumed continued

Meal	Consumer	Condition			Significance
		W	AS	NS	
Evening	M - Low	40.1 (4.1)	40.1 (9.4)	40.1 (11.7)	F(g)(1,22)=0.13, p=0.73 F(c)(1,22)=0.89, p=0.36 F(gc)(1,22)=0.07, p=0.80
	M - High	44.6 (5.5)	42.4 (7.7)	42.8 (5.9)	
	F - Low	39.1 (16.5)	41.4 (16.1)	40.6 (17.9)	
	F - High	44.3 (7.6)	44.7 (5.1)	43.4 (8.4)	
		F(d)(2,48)=0.02, p=0.98 F(gd)(2,48)=0.24, p=0.79 F(cd)(2,48)=0.20, p=0.82			F(gcd)(2,48)=0.01, p=0.99
Day 2	M - Low	30.3 (5.3)	30.8 (14.3)	38.2 (24.0)	F(g)(1,25)=3.09, p=0.09 F(c)(1,25)=0.11, p=0.74 F(gc)(1,25)=0.08, p=0.79
	M - High	28.8 (6.4)	34.0 (10.0)	42.8 (21.2)	
	F - Low	34.8 (9.5)	41.8 (20.6)	47.2 (19.4)	
	F - High	31.7 (9.2)	35.7 (22.0)	33.2 (28.8)	
		F(d)(2,54)=2.49, p=0.09 F(gd)(2,54)=0.34, p=0.71 F(cd)(2,54)=0.09, p=0.91			F(gcd)(2,54)=0.56, p=0.58

Proportions of Protein Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	13.8 (0.9)	13.8 (1.1)	14.1 (1.4)	F(g)(1,26)=1.81, p=0.19 **F(c)(1,26)=4.62, p=0.04** F(gc)(1,26)=0.14, p=0.72
	M - High	13.1 (1.5)	12.9 (1.6)	13.5 (1.5)	
	F - Low	13.4 (1.3)	13.6 (2.0)	13.2 (1.1)	
	F - High	13.1 (2.0)	12.6 (1.4)	12.8 (1.2)	
		F(d)(2,56)=0.36, p=0.70 F(gd)(2,56)=1.05, p=0.34 F(cd)(2,56)=0.54, p=0.58			F(gcd)(2,56)=0.19, p=0.83
Tea	M - Low	16.9 (1.4)	17.2 (2.9)	17.0 (2.3)	**F(g)(1,24)=5.54, p=0.03** F(c)(1,24)=2.78, p=0.11 F(gc)(1,24)=2.22, p=0.15
	M - High	16.5 (1.7)	16.4 (1.7)	16.2 (1.9)	
	F - Low	16.4 (2.5)	17.0 (2.5)	16.3 (2.8)	
	F - High	15.1 (1.5)	14.8 (1.7)	14.8 (1.9)	
		F(d)(2,52)=0.72, p=0.49 F(gd)(2,52)=0.05, p=0.95 F(cd)(2,52)=1.42, p=0.25			F(gcd)(2,52)=0.33, p=0.72
Evening	M - Low	9.7 (3.0)	9.9 (2.5)	8.5 (3.3)	F(g)(1,22)=0.10, p=0.75 **F(c)(1,22)=8.39, p=0.01** F(gc)(1,22)=0.15, p=0.71
	M - High	9.2 (1.6)	8.7 (2.0)	8.5 (2.8)	
	F - Low	8.9 (2.7)	10.3 (2.5)	10.9 (8.3)	
	F - High	8.0 (2.4)	7.3 (2.3)	8.9 (1.4)	
		F(d)(2,48)=0.02, p=0.98 F(gd)(2,48)=1.01, p=0.37 F(cd)(2,48)=0.51, p=0.61			F(gcd)(2,48)=0.30, p=0.75
Day 2	M - Low	14.8 (2.8)	15.5 (10.7)	17.5 (6.0)	F(g)(1,25)=0.01, p=0.93 **F(c)(1,25)=4.77, p=0.04** F(gc)(1,25)=0.08, p=0.79
	M - High	11.0 (2.6)	10.6 (2.1)	16.7 (5.6)	
	F - Low	14.0 (3.1)	18.3 (8.0)	15.8 (5.4)	
	F - High	11.2 (5.2)	13.1 (4.7)	11.1 (4.3)	
		F(d)(2,54)=2.05, p=0.14 F(gd)(2,54)=3.10, p=0.05 F(cd)(2,54)=0.46, p=0.63			F(gcd)(2,54)=0.53, p=0.59

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.11: Cumulative Test Meal Intake - Proportions of All Macronutrients consumed (%kcal) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 3

Proportions of Carbohydrate Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	45.0 (2.1)	44.4 (1.6)	44.9 (1.3)	F(g)(1,26)=3.31, p=0.08
	M - High	44.7 (2.4)	45.5 (2.8)	44.8 (2.4)	F(c)(1,26)=0.65, p=0.43
	F - Low	45.2 (3.6)	45.7 (3.1)	44.7 (2.3)	F(gc)(1,26)=3.31, p=0.08
	F - High	44.8 (2.6)	44.2 (1.5)	44.1 (1.6)	
		F(d)(2,56)=0.92, p=0.40 F(gd)(2,56)=0.78, p=0.46 F(cd)(2,56)=0.05, p=0.95			**F(gcd)(2,56)=3.44, p=0.04**
+ Tea	M - Low	49.3 (1.5)	48.2 (2.4)	49.4 (2.1)	F(g)(1,26)=2.09, p=0.16
	M - High	50.3 (4.5)	50.2 (3.4)	50.4 (4.3)	F(c)(1,26)=0.11, p=0.74
	F - Low	51.4 (4.9)	51.9 (4.3)	51.4 (4.9)	F(gc)(1,26)=0.11, p=0.75
	F - High	51.3 (3.0)	51.3 (3.0)	51.6 (2.6)	
		F(d)(2,56)=0.36, p=0.70 F(gd)(2,56)=0.97, p=0.39 F(cd)(2,56)=0.09, p=0.92			F(gcd)(2,56)=1.00, p=0.38
+ Evening	M - Low	48.1 (2.6)	46.6 (3.3)	48.3 (3.1)	F(g)(1,25)=0.80, p=0.38
	M - High	48.3 (2.4)	47.7 (2.9)	48.5 (2.4)	F(c)(1,25)=0.33, p=0.57
	F - Low	49.6 (7.0)	48.9 (6.9)	46.4 (5.5)	F(gc)(1,25)=0.24, p=0.63
	F - High	49.3 (2.3)	49.6 (2.4)	50.5 (3.0)	
		F(d)(2,54)=0.40, p=0.67 F(gd)(2,54)=1.20, p=0.31 F(cd)(2,54)=1.60, p=0.21			F(gcd)(2,54)=1.97, p=0.15
+ Day 2	M - Low	49.2 (4.1)	47.0 (3.8)	47.9 (4.5)	F(g)(1,24)=0.09, p=0.77
	M - High	48.3 (4.3)	46.9 (3.7)	46.8 (4.7)	F(c)(1,24)=0.00, p=0.95
	F - Low	48.4 (5.0)	48.8 (5.2)	46.2 (4.1)	F(gc)(1,24)=0.39, p=0.54
	F - High	50.6 (6.2)	47.8 (3.6)	51.0 (2.7)	
		F(d)(2,52)=2.58, p=0.09 F(gd)(2,52)=0.12, p=0.89 F(cd)(2,52)=1.27, p=0.29			**F(gcd)(2,52)=3.40, p=0.04**

Proportions of Fat consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	38.6 (2.4)	39.3 (2.3)	38.4 (1.9)	**F(g)(1,26)=5.50, p=0.03**
	M - High	39.5 (3.1)	38.9 (2.8)	39.0 (2.7)	F(c)(1,26)=3.58, p=0.07
	F - Low	38.6 (4.3)	37.8 (4.0)	39.3 (2.2)	F(gc)(1,26)=4.03, p=0.06
	F - High	39.5 (2.8)	40.5 (1.5)	40.4 (2.2)	
		F(d)(2,56)=0.31, p=0.74 F(gd)(2,56)=2.09, p=0.13 F(cd)(2,56)=0.12, p=0.89			**F(gcd)(2,56)=3.20, p=0.05**
+ Tea	M - Low	32.1 (2.1)	33.4 (3.5)	31.7 (2.6)	F(g)(1,26)=0.48, p=0.50
	M - High	31.8 (4.7)	32.0 (3.3)	31.6 (4.7)	F(c)(1,26)=0.18, p=0.67
	F - Low	30.5 (3.9)	29.5 (3.3)	30.6 (4.1)	F(gc)(1,26)=0.63, p=0.43
	F - High	31.1 (2.0)	31.6 (2.5)	31.1 (2.2)	
		F(d)(2,56)=0.38, p=0.68 F(gd)(2,56)=1.75, p=0.18 F(cd)(2,56)=0.04, p=0.96			F(gcd)(2,56)=1.94, p=0.15

Proportions of Fat Consumed continued

Meal	Consumer	Condition			Significance
		W	AS	NS	
+ Evening	M - Low	34.6 (2.4)	36.1 (4.5)	34.3 (4.0)	F(g)(1,25)=0.01, p=0.93 F(c)(1,25)=0.11, p=0.75 F(gc)(1,25)=0.01, p=0.93
	M - High	35.6 (2.6)	35.7 (3.5)	34.7 (2.2)	
	F - Low	34.2 (6.7)	34.5 (6.3)	35.3 (7.8)	
	F - High	35.5 (2.8)	35.5 (2.1)	34.0 (3.7)	
		F(d)(2,54)=0.63, p=0.54 F(gd)(2,54)=0.16, p=0.85 F(cd)(2,54)=0.68, p=0.51			F(gcd)(2,54)=0.74, p=0.48
+ Day 2	M - Low	32.8 (3.0)	33.5 (5.3)	33.2 (7.7)	F(g)(1,24)=0.31, p=0.58 F(c)(1,24)=0.19, p=0.67 F(gc)(1,24)=0.28, p=0.60
	M - High	32.5 (2.6)	38.0 (3.8)	34.9 (4.7)	
	F - Low	34.9 (4.6)	34.2 (5.9)	35.7 (5.8)	
	F - High	33.9 (3.5)	35.0 (4.1)	34.4 (4.3)	
		F(d)(2,52)=1.14, p=0.33 F(gd)(2,52)=0.69, p=0.50 F(cd)(2,52)=0.97, p=0.39			F(gcd)(2,52)=0.30, p=0.74

Proportions of Protein Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch	M - Low	13.8 (0.9)	13.8 (1.1)	14.1 (1.4)	F(g)(1,26)=1.81, p=0.19 **F(c)(1,26)=4.62, p=0.04** F(gc)(1,26)=0.14, p=0.72
	M - High	13.1 (1.5)	12.9 (1.6)	13.5 (1.5)	
	F - Low	13.4 (1.3)	13.6 (2.0)	13.2 (1.1)	
	F - High	13.1 (2.0)	12.6 (1.4)	12.8 (1.2)	
		F(d)(2,56)=0.36, p=0.70 F(gd)(2,56)=1.05, p=0.34 F(cd)(2,56)=0.54, p=0.58			F(gcd)(2,56)=0.19, p=0.83
+ Tea	M - Low	15.4 (1.3)	15.3 (1.9)	15.7 (1.7)	**F(g)(1,26)=7.54, p=0.01** **F(c)(1,26)=4.85, p=0.04** F(gc)(1,26)=0.96, p=0.34
	M - High	14.7 (0.9)	14.5 (0.9)	14.7 (1.0)	
	F - Low	14.6 (1.5)	15.1 (1.8)	14.5 (1.6)	
	F - High	14.2 (1.6)	13.7 (0.8)	13.8 (1.0)	
		F(d)(2,56)=0.05, p=0.96 F(gd)(2,56)=1.08, p=0.35 F(cd)(2,56)=0.98, p=0.38			F(gcd)(2,56)=1.20, p=0.31
+ Evening	M - Low	13.7 (1.5)	13.6 (2.3)	13.7 (2.0)	F(g)(1,25)=2.67, p=0.12 **F(c)(1,25)=5.20, p=0.03** F(gc)(1,25)=0.27, p=0.61
	M - High	12.8 (0.6)	12.4 (0.7)	12.7 (0.8)	
	F - Low	13.1 (1.7)	13.5 (1.6)	12.7 (1.8)	
	F - High	12.0 (1.3)	11.7 (0.8)	12.5 (1.2)	
		F(d)(2,54)=0.23, p=0.80 F(gd)(2,54)=0.23, p=0.80 F(cd)(2,54)=2.30, p=0.11			F(gcd)(2,54)=1.38, p=0.26
+ Day 2	M - Low	14.1 (1.2)	14.0 (3.8)	14.3 (3.1)	F(g)(1,24)=3.51, p=0.07 **F(c)(1,24)=6.94, p=0.02** F(gc)(1,24)=0.43, p=0.52
	M - High	12.2 (1.2)	12.0 (0.8)	13.6 (1.9)	
	F - Low	13.4 (1.9)	14.4 (2.0)	12.7 (2.6)	
	F - High	11.5 (2.8)	11.9 (1.7)	12.7 (2.3)	
		F(d)(2,52)=0.36, p=0.70 F(gd)(2,52)=0.58, p=0.57 F(cd)(2,52)=1.45, p=0.24			F(gcd)(2,52)=0.42, p=0.66

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.12: Results of all Covariate Tests in all Subjective ANCOVA Analyses

Analyses	All Participants				Females Only	
Covariates	B.M.I.		Restraint		Restraint	
	Test t	p	Test t	p	Test t	p
Hunger	1.23	0.23	0.72	0.48	-0.31	0.76
Desire to Eat	1.30	0.20	0.46	0.65	-0.45	0.66
Fullness	-1.99	0.06	-0.38	0.71	0.63	0.54
Prospective Consumption	**2.02**	**0.05**	0.84	0.41	-0.31	0.76
Thirst	**3.41**	**0.002**	0.75	0.46	-0.79	0.44
Desire to Drink	**4.40**	**0.001**	1.49	0.15	-0.56	0.59

APPENDIX 8.13: Results of all Covariate Tests in all Behavioural ANCOVA Analyses

Analyses		All Participants				Females Only	
Covariates		B.M.I.		Restraint		Restraint	
		Test t	p	Test t	p	Test t	p
Test Meal	Lunch	0.92	0.37	0.90	0.38	**3.62**	**0.003**
Intake -	Tea	**-2.14**	**0.05**	0.10	0.92	0.18	0.86
Weight	Evening	0.68	0.50	0.61	0.55	1.00	0.33
of Food	Following Day	0.53	0.60	0.53	0.60	1.22	0.24
Consumed	Lunch + Tea	0.43	0.67	0.61	0.55	**2.10**	**0.05**
	+ Evening	0.63	0.53	0.74	0.47	1.91	0.08
	+ Following Day	0.69	0.50	0.77	0.45	**2.42**	**0.03**
Test Meal	Lunch	0.30	0.77	0.53	0.60	**2.31**	**0.04**
Intake -	Tea	0.45	0.66	-0.07	0.94	-0.72	0.49
Energy	Evening	0.33	0.74	1.19	0.25	0.86	0.40
Consumed	Following Day	0.14	0.89	**-2.11**	**0.05**	0.67	0.51
	Lunch + Tea	0.46	0.65	0.20	0.84	0.71	0.49
	+ Evening	0.58	0.57	0.89	0.38	0.94	0.36
	+ Following Day	0.90	0.38	-0.17	0.87	-0.39	0.70
Total	Lunch	0.30	0.77	0.53	0.60	**2.31**	**0.04**
Energy	+ Tea	0.46	0.65	0.20	0.84	0.71	0.49
Intake	+ Evening	0.55	0.57	0.89	0.38	0.94	0.36
	+ Following Day	0.90	0.38	-0.17	0.87	-0.39	0.70
Test Meal	Lunch	-1.80	0.08	**2.06**	**0.05**	1.04	0.32
Intake -	Tea	-1.45	0.16	-1.04	0.31	-1.35	0.20
% Energy	Evening	0.25	0.81	0.20	0.84	1.87	0.09
consumed	Following Day	0.13	0.89	1.57	0.13	**2.22**	**0.05**
from CHO	Lunch + Tea	0.51	0.62	-0.33	0.75	-1.34	0.20
	+ Evening	0.37	0.71	-0.30	0.77	0.26	0.80
	+ Following Day	-0.12	0.91	0.48	0.64	1.50	0.16
Test Meal	Lunch	1.31	0.20	**-2.65**	**0.01**	**-2.33**	**0.04**
Intake -	Tea	-1.25	0.23	0.56	0.58	1.29	0.22
% Energy	Evening	-0.10	0.92	-0.52	0.61	-1.38	0.19
consumed	Following Day	-0.12	0.91	-0.99	0.33	-1.49	0.16
from Fat	Lunch + Tea	-0.24	0.82	-0.34	0.73	1.17	0.26
	+ Evening	-0.25	0.80	-0.18	0.86	-0.36	0.72
	+ Following Day	0.09	0.93	-0.31	0.76	-0.68	0.51
Test Meal	Lunch	0.83	0.41	1.30	0.21	**2.30**	**0.04**
Intake -	Tea	-1.38	0.18	1.68	0.11	1.26	0.23
% Energy	Evening	**2.61**	**0.02**	1.38	0.18	0.48	0.64
consumed	Following Day	0.13	0.89	0.13	0.13	**2.12**	**0.05**
from	Lunch + Tea	-0.89	0.39	-0.88	0.06	1.49	0.16
Protein	+ Evening	0.30	0.77	0.30	0.22	0.87	0.40
	+ Following Day	-0.15	0.88	-0.15	0.10	1.52	0.15

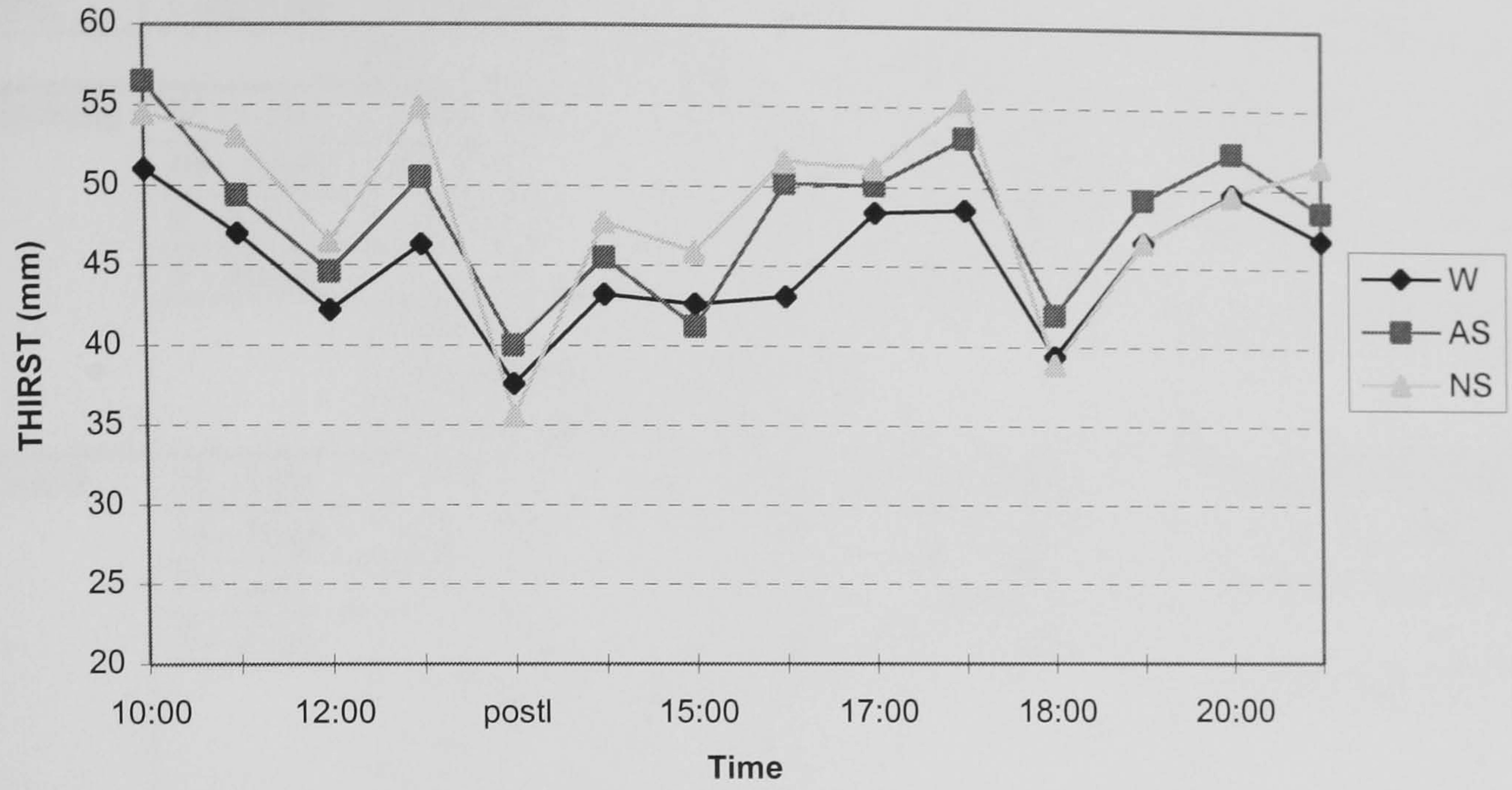
APPENDIX 8.14: Energy and Macronutrient Content of all Foods used in Study 4.

Foods - Morning Snacks and Afternoon Snacks	Energy (kcal/ptn)	Carbohydrate (g/ptn)	Fat (g/ptn)	Protein (g/ptn)
Crisps	159.5	13.35	11.0	1.75
Cheese Biscuits	160.5	16.3	9.1	3.30
Cheese Crackers	156.0	13.8	10.2	2.20
Chocolate Biscuits	155.0	20.1	7.3	2.00
Chocolate Chip Cookies	156.0	20.0	7.7	1.70
Digestive Biscuits	146.0	19.8	6.4	2.00
Foods - Lunch	**Energy (kcal/g)**	**Carbohydrate (g/g)**	**Fat (g/g)**	**Protein (g/g)**
Cream Cheese Sandwiches **	2.05	0.288	0.057	0.094
Honey Roast Turkey Sandwiches **	2.02	0.256	0.052	0.130
Coleslaw	0.64	0.051	0.041	0.017
Cheese and Tomato Pizza	2.42	0.292	0.092	0.106
Jelly Babies ***	3.36	0.784	0	0.052
Marshmallows ***	3.32	0.805	0	0.034
Popcorn ***	4.09	0.810	0.083	0.027
Strawberry Yoghurt	0.91	0.142	0.017	0.047
Water	0	0	0	0
Foods - Tea	**Energy (kcal/g)**	**Carbohydrate (g/g)**	**Fat (g/g)**	**Protein (g/g)**
Vegetable Lasagne	1.09	0.112	0.059	0.035
Peas *	0.62	0.090	0.007	0.049
Sweetcorn *	0.84	0.160	0.005	0.028
Chocolate Biscuits	5.06	0.657	0.240	0.068
Apples	0.45	0.115	0.001	0.003
Water	0	0	0	0
Foods - Snackbox	**Energy (kcal/g or kcal/ptn)**	**Carbohydrate (g/g or g/ptn)**	**Fat (g/g or g/ptn)**	**Protein (g/g or g/ptn)**
Bread Rolls (brown)	2.36	0.450	0.019	0.097
Bread Rolls (white)	2.48	0.470	0.028	0.088
Margarine (ptn)	63.5	0.10	7.00	0.02
Cheese (ptn)	82.4	0.02	6.88	5.10
Jam (ptn)	52.2	13.80	0	0.12
Crisps (ptn)	159.5	13.35	11.00	1.75
Biscuits (ptn)	155.0	20.10	7.30	2.00
Yoghurts (ptn)	85.8	14.58	0.12	3.66
Apples	0.45	0.115	0.001	0.003

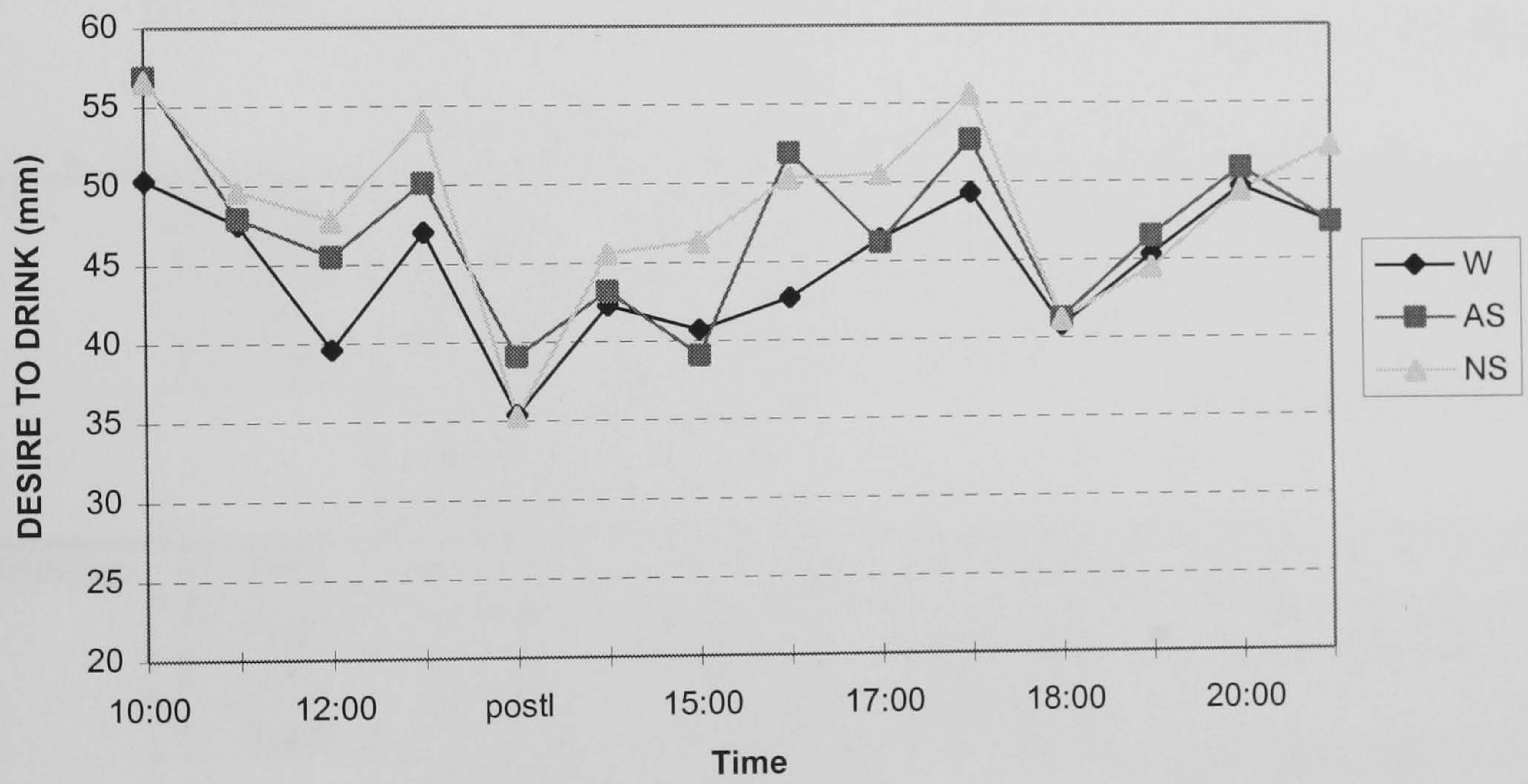
* only one vegetable item was given to each participant, depending on preference
** only one type of sandwich was given to each participant, depending on preference
*** only one item of confectionery was given to each participant, depending on preference

Cream Cheese Sandwich Recipe (/95g):
70g brown bread, 25g Philadelphia Light cream cheese
Honey Roast Turkey Sandwiches (/105g):
70g brown bread, 30g honey roast turkey slices, 5g margarine

APPENDIX 8.15: Temporal Profile for Subjective Measures of THIRST - Preload by Time - Study 4



APPENDIX 8.16: Temporal Profile for Subjective Measures of DESIRE TO DRINK - Preload by Time - Study 4



APPENDIX 8.17: Individual Test Meal Intake - Weight Consumed (gram) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	105 (106)	128 (136)	131 (146)	F(g)(1,27)=2.91, p=0.10
	M - High	67 (81)	127 (102)	75 (43)	F(c)(1,27)=1.20, p=0.28
	F - Low	104 (182)	33 (36)	61 (93)	F(gc)(1,27)=0.00, p=0.95
	F - High	47 (31)	31 (23)	15 (28)	
		F(d)(2,56)=0.22, p=0.80 **F(gd)(2,56)=3.51, p=0.04** F(cd)(2,56)=1.48, p=0.24			F(gcd)(2,56)=0.10, p=0.91
Lunch	M - Low	584 (192)	637 (270)	650 (250)	**F(g)(1,27)=5.84, p=0.02**
	M - High	543 (124)	554 (150)	497 (104)	F(c)(1,27)=0.08, p=0.77
	F - Low	360 (128)	373 (135)	314 (91)	**F(gc)(1,27)=4.69, p=0.04**
	F - High	478 (179)	555 (165)	470 (195)	
		F(d)(2,56)=2.36, p=0.10 F(gd)(2,56)=0.63, p=0.54 F(cd)(2,56)=0.60, p=0.55			F(gcd)(2,56)=1.39, p=0.26
After-noon	M - Low	86 (107)	71 (104)	105 (100)	F(g)(1,27)=3.80, p=0.06
	M - High	71 (73)	53 (35)	59 (43)	F(c)(1,27)=0.21, p=0.65
	F - Low	28 (28)	35 (36)	8 (14)	F(gc)(1,27)=0.85, p=0.37
	F - High	41 (45)	34 (34)	30 (42)	
		F(d)(2,56)=0.60, p=0.55 F(gd)(2,56)=2.37, p=0.10 F(cd)(2,56)=0.25, p=0.78			F(gcd)(2,56)=1.35, p=0.27
Tea	M - Low	801 (212)	716 (395)	770 (199)	F(g)(1,27)=0.69, p=0.41
	M - High	720 (209)	699 (193)	622 (135)	F(c)(1,27)=0.10, p=0.75
	F - Low	584 (181)	611 (195)	539 (164)	F(gc)(1,27)=2.44, p=0.13
	F - High	715 (232)	742 (281)	736 (235)	
		F(d)(2,56)=0.93, p=0.40 F(gd)(2,56)=1.02, p=0.37 F(cd)(2,56)=0.22, p=0.80			F(gcd)(2,56)=1.55, p=0.22
Evening	M - Low	367 (275)	381 (210)	325 (200)	F(g)(1,27)=1.48, p=0.24
	M - High	256 (148)	243 (205)	162 (121)	F(c)(1,27)=0.18, p=0.68
	F - Low	127 (123)	206 (136)	145 (118)	F(gc)(1,27)=2.45, p=0.13
	F - High	179 (137)	186 (170)	219 (233)	
		F(d)(2,56)=1.15, p=0.33 F(gd)(2,56)=1.60, p=0.21 F(cd)(2,56)=0.43, p=0.65			F(gcd)(2,56)=0.60, p=0.55
Day 2	M - Low	1337 (571)	1385 (578)	1343 (236)	F(g)(1,25)=1.43. p=0.24
	M - High	1237 (396)	1132 (325)	1355 (503)	F(c)(1,25)=0.31, p=0.58
	F - Low	1138 (281)	1177 (262)	1126 (513)	F(gc)(1,25)=0.08, p=0.78
	F - High	951 (373)	1408 (809)	1010 (369)	
		F(d)(2,54)=0.79, p=0.46 F(gd)(2,54)=2.49, p=0.09 F(cd)(2,54)=0.35, p=0.71			F(gcd)(2,54)=2.45, p=0.10

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.18: Cumulative Test Meal Intake - Weight Consumed (gram) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	105 (106)	128 (136)	131 (146)	F(g)(1,27)=2.91, p=0.10 F(c)(1,27)=1.20, p=0.28 F(gc)(1,27)=0.00, p=0.95
	M - High	67 (81)	127 (102)	75 (43)	
	F - Low	104 (182)	33 (36)	61 (93)	
	F - High	47 (31)	31 (23)	15 (28)	
		F(d)(2,56)=0.22, p=0.80 **F(gd)(2,56)=3.51, p=0.04** F(cd)(2,56)=1.48, p=0.24			F(gcd)(2,56)=0.10, p=0.91
+ Lunch	M - Low	689 (251)	765 (360)	781 (339)	**F(g)(1,27)=6.89, p=0.02** F(c)(1,27)=0.05, p=0.82 F(gc)(1,27)=2.85, p=0.10
	M - High	610 (162)	681 (236)	572 (116)	
	F - Low	463 (184)	405 (135)	376 (132)	
	F - High	525 (186)	586 (164)	485 (192)	
		F(d)(2,56)=2.02, p=0.14 F(gd)(2,56)=1.45, p=0.24 F(cd)(2,56)=1.52, p=0.23			F(gcd)(2,56)=1.30, p=0.28
+ Afternoon	M - Low	775 (298)	836 (426)	886 (400)	**F(g)(1,27)=7.94, p=0.01** F(c)(1,27)=0.10, p=0.75 F(gc)(1,27)=2.98, p=0.10
	M - High	681 (206)	734 (255)	631 (140)	
	F - Low	492 (185)	440 (141)	383 (135)	
	F - High	566 (167)	619 (154)	515 (183)	
		F(d)(2,56)=1.63, p=0.21 F(gd)(2,56)=1.74, p=0.19 F(cd)(2,56)=1.42, p=0.25			F(gcd)(2,56)=1.70, p=0.19
+ Tea	M - Low	1576 (387)	1553 (678)	1657 (501)	**F(g)(1,27)=5.29, p=0.03** F(c)(1,27)=0.00, p=0.99 **F(gc)(1,27)=4.16, p=0.05**
	M - High	1400 (200)	1432 (339)	1253 (150)	
	F - Low	1076 (324)	1051 (251)	922 (290)	
	F - High	1281 (378)	1362 (377)	1251 (390)	
		F(d)(2,56)=1.70, p=0.19 F(gd)(2,56)=0.44, p=0.65 F(cd)(2,56)=1.10, p=0.34			F(gcd)(2,56)=2.25, p=0.12
+ Evening	M - Low	1944 (507)	1934 (732)	1982 (677)	**F(g)(1,27)=5.35, p=0.03** F(c)(1,27)=0.03, p=0.87 **F(gc)(1,27)=4.96, p=0.03**
	M - High	1657 (263)	1676 (479)	1415 (147)	
	F - Low	1206 (379)	1257 (347)	1068 (326)	
	F - High	1459 (395)	1548 (509)	1470 (474)	
		F(d)(2,56)=2.52, p=0.09 F(gd)(2,56)=0.19, p=0.83 F(cd)(2,56)=0.42, p=0.66			F(gcd)(2,56)=2.49, p=0.09
+ Day 2	M - Low	3280 (602)	3319 (671)	3325 (739)	**F(g)(1,26)=5.83. p=0.02** F(c)(1,26)=0.19, p=0.66 F(gc)(1,26)=2.96, p=0.10
	M - High	2868 (417)	2807 (524)	2770 (540)	
	F - Low	2340 (618)	2433 (540)	2194 (722)	
	F - High	2410 (602)	2955 (1075)	2481 (772)	
		F(d)(2,54)=1.92, p=0.16 F(gd)(2,54)=1.96, p=0.15 F(cd)(2,54)=0.46, p=0.63			F(gcd)(2,54)=0.88, p=0.42

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.19: Individual Test Meal Intake - Energy Consumed (kcal) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Meal	Consumer	Condition W	AS	NS	Significance
Morning	M - Low	551 (555)	485 (511)	504 (533)	**F(g)(1,27)=6.08, p=0.02**
	M - High	310 (336)	645 (414)	396 (164)	F(c)(1,27)=0.10, p=0.75
	F - Low	113 (111)	169 (183)	188 (169)	F(gc)(1,27)=0.08, p=0.78
	F - High	252 (141)	140 (131)	80 (147)	
		F(d)(2,56)=2.31, p=0.11 F(gd)(2,56)=3.02, p=0.06 **F(cd)(2,56)=3.54, p=0.04**			**F(gcd)(2,56)=9.47, p=0.001**
Lunch	M - Low	1042 (256)	1099 (351)	1126 (343)	**F(g)(1,27)=12.18, p=0.002**
	M - High	957 (208)	952 (275)	898 (208)	F(c)(1,27)=0.01, p=0.90
	F - Low	591 (209)	603 (232)	542 (121)	**F(gc)(1,27)=6.18, p=0.02**
	F - High	794 (244)	937 (270)	796 (324)	
		F(d)(2,56)=1.59, p=0.21 F(gd)(2,56)=0.77, p=0.47 F(cd)(2,56)=0.65, p=0.53			F(gcd)(2,56)=1.24, p=0.30
After-noon	M - Low	451 (558)	374 (542)	549 (523)	F(g)(1,27)=3.82, p=0.06
	M - High	372 (384)	275 (182)	308 (223)	F(c)(1,27)=0.21, p=0.65
	F - Low	146 (146)	182 (186)	38 (70)	F(gc)(1,27)=0.86, p=0.36
	F - High	216 (235)	177 (177)	157 (221)	
		F(d)(2,56)=0.58, p=0.56 F(gd)(2,56)=2.39, p=0.10 F(cd)(2,56)=0.25, p=0.78			F(gcd)(2,56)=1.34, p=0.27
Tea	M - Low	846 (233)	766 (408)	843 (205)	F(g)(1,27)=2.83, p=0.10
	M - High	748 (203)	804 (166)	734 (145)	F(c)(1,27)=0.00, p=0.97
	F - Low	621 (193)	674 (214)	580 (213)	F(gc)(1,27)=1.44, p=0.24
	F - High	735 (238)	731 (225)	733 (177)	
		F(d)(2,56)=0.16, p=0.85 F(gd)(2,56)=0.22, p=0.81 F(cd)(2,56)=0.13, p=0.88			F(gcd)(2,56)=1.38, p=0.26
Evening	M - Low	1033 (630)	1063 (718)	952 (574)	F(g)(1,27)=2.73, p=0.11
	M - High	680 (468)	673 (444)	642 (327)	F(c)(1,27)=0.07, p=0.79
	F - Low	356 (192)	493 (344)	380 (147)	F(gc)(1,27)=3.97, p=0.06
	F - High	606 (243)	677 (418)	654 (506)	
		F(d)(2,56)=0.86, p=0.43 F(gd)(2,56)=0.46, p=0.63 F(cd)(2,56)=0.28, p=0.75			F(gcd)(2,56)=0.01, p=0.99
Day 2	M - Low	2322 (562)	2538 (354)	2595 (886)	**F(g)(1,25)=6.36, p=0.02**
	M - High	2715 (1017)	2465 (775)	2520 (1017)	F(c)(1,25)=0.52, p=0.48
	F - Low	2002 (451)	1715 (297)	1724 (423)	F(gc)(1,25)=0.17, p=0.69
	F - High	1608 (554)	2094 (662)	1525 (361)	
		F(d)(2,54)=0.29, p=0.75 F(gd)(2,54)=1.19, p=0.31 F(cd)(2,54)=0.52, p=0.60			**F(gcd)(2,54)=3.43, p=0.04**

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.20: Cumulative Test Meal Intake - Energy Consumed (kcal) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Meals	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	551 (555)	485 (511)	504 (533)	**F(g)(1,27)=6.08, p=0.02** F(c)(1,27)=0.10, p=0.75 F(gc)(1,27)=0.08, p=0.78
	M - High	310 (336)	645 (414)	396 (164)	
	F - Low	113 (111)	169 (183)	188 (169)	
	F - High	252 (141)	140 (131)	80 (147)	
		F(d)(2,56)=2.31, p=0.11 F(gd)(2,56)=3.02, p=0.06 **F(cd)(2,56)=3.54, p=0.04**			**F(gcd)(2,56)=9.47, p=0.001**
+ Lunch	M - Low	1593 (735)	1584 (790)	1630 (783)	**F(g)(1,27)=11.71, p=0.002** F(c)(1,27)=0.02, p=0.88 F(gc)(1,27)=2.08, p=0.16
	M - High	1267 (411)	1597 (628)	1294 (334)	
	F - Low	704 (169)	772 (276)	730 (216)	
	F - High	1046 (290)	1077 (327)	876 (317)	
		F(d)(2,56)=3.40, p=0.04 F(gd)(2,56)=0.74, p=0.48 **F(cd)(2,56)=3.07, p=0.05**			F(gcd)(2,56)=1.67, p=0.20
+ Afternoon	M - Low	2044 (1133)	1958 (1263)	2179 (1254)	**F(g)(1,27)=10.00, p=0.004** F(c)(1,27)=0.09, p=0.76 F(gc)(1,27)=1.90, p=0.18
	M - High	1639 (683)	1872 (728)	1602 (466)	
	F - Low	850 (253)	954 (331)	768 (241)	
	F - High	1262 (272)	1255 (316)	1033 (287)	
		F(d)(2,56)=1.53, p=0.23 F(gd)(2,56)=1.47, p=0.24 F(cd)(2,56)=2.07, p=0.14			F(gcd)(2,56)=1.93, p=0.15
+ Tea	M - Low	2889 (1144)	2724 (1290)	3022 (1405)	**F(g)(1,27)=11.58, p=0.002** F(c)(1,27)=0.08, p=0.78 F(gc)(1,27)=2.57, p=0.12
	M - High	2387 (622)	2676 (805)	2336 (533)	
	F - Low	1471 (357)	1628 (387)	1348 (423)	
	F - High	1997 (420)	1985 (345)	1767 (426)	
		F(d)(2,56)=1.47, p=0.24 F(gd)(2,56)=1.34, p=0.27 F(cd)(2,56)=1.67, p=0.20			F(gcd)(2,56)=2.97, p=0.06
+ Evening	M - Low	3922 (1703)	3787 (1860)	3974 (1938)	**F(g)(1,27)=8.94, p=0.01** F(c)(1,27)=0.09, p=0.77 F(gc)(1,27)=3.54, p=0.07
	M - High	3068 (959)	3348 (1129)	2978 (734)	
	F - Low	1826 (471)	2121 (611)	1728 (431)	
	F - High	2603 (509)	2662 (629)	2421 (675)	
		F(d)(2,56)=1.97, p=0.15 F(gd)(2,56)=0.59, p=0.56 F(cd)(2,56)=0.48, p=0.62			F(gcd)(2,56)=1.80, p=0.18
+ Day 2	M - Low	6245 (1713)	6325 (1917)	6569 (2607)	**F(g)(1,26)=10.24, p=0.004** F(c)(1,26)=0.00, p=0.99 F(gc)(1,26)=1.64, p=0.21
	M - High	5714 (1983)	5813 (1869)	5498 (1470)	
	F - Low	3828 (762)	3836 (760)	3452 (671)	
	F - High	4211 (746)	4756 (849)	3946 (770)	
		F(d)(2,54)=1.56, p=0.22 F(gd)(2,54)=1.35, p=0.27 F(cd)(2,54)=0.94, p=0.40			F(gcd)(2,54)=0.46, p=0.63

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.21: Cumulative Total Energy Intake (kcal) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Meal	Consumer	Condition			Significance
		W	AS	NS	
Lunch + Morning + Morning Drinks	M - Low	1593 (735)	1594 (790)	1880 (783)	**F(g)(1,27)=11.71, p=0.002** F(c)(1,27)=0.02, p=0.88 F(gc)(1,27)=2.08, p=0.16
	M - High	1267 (411)	1607 (628)	1544 (334)	
	F - Low	704 (169)	782 (276)	980 (216)	
	F - High	1046 (289)	1087 (327)	1126 (317)	
		F(d)(2,56)=10.01, p<0.001 F(gd)(2,56)=0.74, p=0.48 **F(cd)(2,56)=3.07, p=0.05**			F(gcd)(2,56)=1.67, p=0.20
+ Tea + Afternoon + Afternoon Drinks	M - Low	2889 (1144)	2744 (1290)	3522 (1405)	**F(g)(1,27)=11.58, p=0.002** F(c)(1,27)=0.08, p=0.78 F(gc)(1,27)=2.57, p=0.12
	M - High	2387 (622)	2696 (805)	2836 (533)	
	F - Low	1471 (357)	1648 (387)	1848 (423)	
	F - High	1997 (420)	2005 (345)	2267 (426)	
		F(d)(2,56)=16.87, p<0.001 F(gd)(2,56)=1.34, p=0.27 F(cd)(2,56)=1.67, p=0.20			F(gcd)(2,56)=2.97, p=0.06
+ Evening	M - Low	3922 (1703)	3807 (1860)	4474 (1938)	**F(g)(1,27)=8.94, p=0.01** F(c)(1,27)=0.09, p=0.77 F(gc)(1,27)=3.54, p=0.07
	M - High	3068 (959)	3368 (1129)	3478 (734)	
	F - Low	1826 (471)	2141 (611)	2574 (654)	
	F - High	2603 (509)	2682 (629)	2921 (675)	
		F(d)(2,56)=8.45, p=0.001 F(gd)(2,56)=0.59, p=0.56 F(cd)(2,56)=0.48, p=0.62			F(gcd)(2,56)=1.80, p=0.18
+ Day 2	M - Low	6245 (1713)	6345 (1917)	7069 (2607)	**F(g)(1,26)=10.24, p=0.004** F(c)(1,26)=0.00, p=0.99 F(gc)(1,26)=1.64, p=0.21
	M - High	5714 (1983)	5833 (1869)	5998 (1470)	
	F - Low	3828 (762)	3856 (760)	3952 (671)	
	F - High	4211 (746)	4776 (849)	4446 (770)	
		F(d)(2,54)=2.19, p=0.12 F(gd)(2,54)=1.35, p=0.27 F(cd)(2,54)=0.94, p=0.40			F(gcd)(2,54)=0.46, p=0.63

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.22: Individual Test Meal Intake - Proportions of All Macronutrients consumed (%kcal) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Proportions of Carbohydrate Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	37.3 (4.1)	38.3 (4.6)	40.7 (3.0)	F(g)(1,11)=0.59, p=0.46
	M - High	38.3 (6.8)	41.4 (3.1)	45.5 (12.6)	F(c)(1,11)=0.51, p=0.49
	F - Low	57.3 (37.9)	39.9 (6.3)	47.8 (18.9)	F(gc)(1,11)=0.31, p=0.59
	F - High	45.0 (10.6)	33.1 (16.1)	51.0 (21.2)	
		F(d)(2,24)=3.21, p=0.06 F(gd)(2,24)=0.26, p=0.77 F(cd)(2,24)=1.40, p=0.27			F(gcd)(2,56)=1.79, p=0.19
Lunch	M - Low	51.6 (2.7)	53.6 (5.0)	51.8 (2.7)	F(g)(1,27)=0.36, p=0.56
	M - High	54.2 (6.9)	55.8 (6.3)	55.7 (7.5)	F(c)(1,27)=0.73, p=0.40
	F - Low	52.3 (3.5)	53.4 (4.6)	51.8 (6.8)	F(gc)(1,27)=0.04, p=0.85
	F - High	54.1 (5.3)	54.9 (5.5)	55.3 (5.0)	
		F(d)(2,56)=1.74, p=0.18 F(gd)(2,56)=0.17, p=0.84 F(cd)(2,56)=0.86, p=0.43			F(gcd)(2,56)=0.01, p=0.99
Afternoon	M - Low	40.9 (6.2)	35.8 (4.3)	42.8 (4.3)	F(g)(1,8)=0.08, p=0.79
	M - High	41.0 (5.1)	36.2 (5.9)	38.5 (6.6)	F(c)(1,8)=2.82, p=0.13
	F - Low	48.3 (0.3)	39.7 (6.1)	49.5 (2.0)	F(gc)(1,8)=0.86, p=0.38
	F - High	38.1 (6.3)	37.0 (5.2)	38.8 (8.7)	
		F(d)(2,18)=4.09, p=0.03 F(gd)(2,18)=0.32, p=0.73 F(cd)(2,18)=2.73, p=0.09			F(gcd)(2,18)=0.93, p=0.41
Tea	M - Low	42.8 (2.8)	43.2 (3.7)	42.7 (2.2)	F(g)(1,27)=0.00, p=0.98
	M - High	46.2 (2.6)	46.2 (2.7)	46.3 (3.3)	F(c)(1,27)=1.82, p=0.19
	F - Low	44.3 (2.7)	45.0 (3.2)	44.9 (3.2)	**F(gc)(1,27)=8.05, p=0.01**
	F - High	43.0 (2.3)	43.7 (2.9)	42.7 (2.3)	
		F(d)(2,56)=0.51, p=0.61 F(gd)(2,56)=0.18, p=0.84 F(cd)(2,56)=0.08, p=0.92			F(gcd)(2,56)=0.33, p=0.72
Evening	M - Low	45.0 (11.4)	47.3 (20.1)	43.0 (3.5)	F(g)(1,26)=0.05, p=0.83
	M - High	53.0 (11.9)	46.3 (8.6)	37.1 (17.6)	F(c)(1,26)=0.50, p=0.49
	F - Low	44.7 (11.8)	48.4 (15.9)	44.6 (13.6)	F(gc)(1,26)=0.04, p=0.85
	F - High	47.8 (13.1)	52.8 (10.9)	49.2 (16.2)	
		F(d)(2,54)=1.26, p=0.29 F(gd)(2,54)=1.03, p=0.37 F(cd)(2,54)=0.29, p=0.75			F(gcd)(2,54)=0.57, p=0.57
Day 2	M - Low	44.2 (7.2)	45.5 (9.9)	51.4 (10.7)	F(g)(1,26)=1.53, p=0.23
	M - High	45.6 (12.9)	43.2 (11.7)	43.3 (10.8)	F(c)(1,26)=0.56, p=0.46
	F - Low	50.3 (9.2)	52.6 (5.9)	48.7 (7.7)	F(gc)(1,26)=1.99, p=0.17
	F - High	51.6 (6.9)	55.0 (12.0)	58.2 (10.8)	
		F(d)(2,54)=1.04, p=0.36 F(gd)(2,54)=0.93, p=0.40 F(cd)(2,54)=0.18, p=0.84			**F(gcd)(2,54)=3.47, p=0.04**

Proportions of Fat Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	54.6 (4.5)	53.8 (5.1)	51.1 (2.5)	F(g)(1,11)=0.79, p=0.39 F(c)(1,11)=0.88, p=0.37 F(gc)(1,11)=0.65, p=0.44
	M - High	53.9 (7.8)	51.0 (4.7)	45.7 (13.8)	
	F - Low	31.3 (46.3)	51.1 (5.6)	43.6 (21.7)	
	F - High	42.6 (19.5)	50.3 (11.6)	34.4 (30.2)	
		F(d)(2,24)=3.42, p=0.05 F(gd)(2,24)=0.57, p=0.57 F(cd)(2,24)=2.62, p=0.09			F(gcd)(2,24)=2.19, p=0.13
Lunch	M - Low	26.6 (2.5)	25.5 (4.8)	26.8 (2.5)	F(g)(1,27)=1.30, p=0.27 F(c)(1,27)=2.41, p=0.13 F(gc)(1,27)=0.04, p=0.85
	M - High	24.1 (5.3)	22.7 (4.5)	23.0 (5.0)	
	F - Low	27.8 (4.1)	28.2 (9.3)	27.5 (6.2)	
	F - High	24.8 (3.7)	24.3 (3.6)	23.6 (3.4)	
		F(d)(2,56)=0.41, p=0.67 F(gd)(2,56)=0.49, p=0.62 F(cd)(2,56)=0.25, p=0.78			F(gcd)(2,56)=0.06, p=0.94
Afternoon	M - Low	50.9 (7.1)	56.4 (5.0)	48.9 (4.9)	F(g)(1,8)=0.00, p=0.97 F(c)(1,8)=2.73, p=0.14 F(gc)(1,8)=0.67, p=0.44
	M - High	51.1 (4.9)	56.4 (6.8)	53.4 (7.0)	
	F - Low	43.4 (1.0)	52.8 (7.0)	41.9 (3.5)	
	F - High	54.6 (7.0)	55.9 (5.8)	54.0 (9.6)	
		F(d)(2,18)=4.21, p=0.03 F(gd)(2,18)=0.33, p=0.73 F(cd)(2,18)=2.52, p=0.11			F(gcd)(2,18)=0.94, p=0.41
Tea	M - Low	43.4 (3.1)	42.7 (3.7)	43.3 (3.2)	F(g)(1,27)=0.16, p=0.69 F(c)(1,27)=0.50, p=0.49 F(gc)(1,27)=3.55, p=0.07
	M - High	40.3 (2.4)	41.0 (2.4)	40.8 (3.7)	
	F - Low	41.5 (3.1)	40.6 (3.0)	41.2 (4.0)	
	F - High	42.9 (2.7)	42.0 (3.8)	42.6 (3.2)	
		F(d)(2,56)=0.61, p=0.55 F(gd)(2,56)=0.42, p=0.66 F(cd)(2,56)=0.25, p=0.78			F(gcd)(2,56)=0.23, p=0.80
Evening	M - Low	43.8 (9.5)	40.9 (16.1)	44.6 (6.2)	F(g)(1,26)=1.01, p=0.32 F(c)(1,26)=1.62, p=0.21 F(gc)(1,26)=0.21, p=0.65
	M - High	30.8 (17.0)	42.3 (10.3)	36.7 (17.8)	
	F - Low	35.8 (18.1)	38.1 (17.4)	44.3 (13.4)	
	F - High	40.8 (11.9)	34.1 (3.6)	39.6 (20.0)	
		F(d)(2,54)=1.57, p=0.22 F(gd)(2,54)=0.49, p=0.62 F(cd)(2,54)=0.06, p=0.94			F(gcd)(2,54)=2.14, p=0.13
Day 2	M - Low	35.6 (7.6)	38.6 (5.4)	30.2 (7.1)	**F(g)(1,26)=4.79. p=0.04** F(c)(1,26)=3.89, p=0.06 F(gc)(1,26)=2.70, p=0.11
	M - High	32.9 (7.3)	35.8 (10.8)	32.8 (7.4)	
	F - Low	32.5 (8.0)	35.0 (6.6)	31.8 (3.6)	
	F - High	26.3 (7.7)	24.2 (5.8)	25.2 (11.5)	
		F(d)(2,54)=2.42, p=0.10 F(gd)(2,54)=1.12, p=0.33 F(cd)(2,54)=0.88, p=0.42			F(gcd)(2,54)=0.37, p=0.69

Proportions of Protein Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	5.5 (1.0)	5.3 (1.1)	5.4 (1.2)	F(g)(1,11)=0.00, p=0.95 F(c)(1,11)=0.08, p=0.78 F(gc)(1,11)=0.64, p=0.44
	M - High	5.4 (1.0)	5.5 (1.5)	6.4 (2.9)	
	F - Low	8.6 (7.8)	6.9 (1.3)	6.2 (3.7)	
	F - High	10.0 (12.1)	14.7 (23.9)	4.3 (3.8)	
		F(d)(2,56)=0.43, p=0.65 F(gd)(2,56)=1.75, p=0.20 F(cd)(2,56)=1.70, p=0.20			F(gcd)(2,56)=1.08, p=0.36
Lunch	M - Low	18.2 (2.2)	17.1 (2.1)	17.7 (2.1)	F(g)(1,27)=0.01, p=0.94 F(c)(1,27)=0.17, p=0.69 F(gc)(1,27)=0.03, p=0.87
	M - High	17.8 (3.7)	17.5 (3.7)	17.4 (4.3)	
	F - Low	16.6 (1.8)	17.3 (2.3)	17.0 (1.3)	
	F - High	17.3 (2.4)	17.0 (2.7)	17.2 (2.5)	
		F(d)(2,56)=0.31, p=0.73 F(gd)(2,56)=1.12, p=0.33 F(cd)(2,56)=0.06, p=0.94			F(gcd)(2,56)=1.05, p=0.36
Afternoon	M - Low	5.2 (0.8)	5.2 (0.7)	5.1 (0.4)	F(g)(1,8)=5.02, p=0.06 F(c)(1,8)=0.05, p=0.82 F(gc)(1,8)=0.53, p=0.49
	M - High	5.0 (0.5)	4.8 (0.4)	5.3 (0.8)	
	F - Low	4.7 (0.4)	4.7 (0.4)	4.9 (0.8)	
	F - High	4.7 (0.3)	4.5 (0.2)	4.5 (0.2)	
		F(d)(2,18)=0.40, p=0.68 F(gd)(2,18)=0.06, p=0.94 F(cd)(2,18)=0.36, p=0.70			F(gcd)(2,18)=0.23, p=0.80
Tea	M - Low	13.3 (1.8)	13.4 (2.3)	13.4 (2.3)	F(g)(1,27)=0.62, p=0.44 F(c)(1,27)=0.50, p=0.49 F(gc)(1,27)=2.77, p=0.11
	M - High	12.6 (2.2)	11.8 (2.1)	11.7 (2.1)	
	F - Low	13.2 (1.4)	13.2 (2.0)	13.0 (1.6)	
	F - High	13.6 (1.8)	13.8 (1.6)	14.1 (1.3)	
		F(d)(2,56)=0.20, p=0.82 F(gd)(2,56)=0.66, p=0.52 F(cd)(2,56)=0.21, p=0.81			F(gcd)(2,56)=1.32, p=0.28
Evening	M - Low	8.5 (3.8)	9.5 (5.8)	9.5 (4.3)	F(g)(1,26)=0.01, p=0.91 F(c)(1,26)=0.59, p=0.45 F(gc)(1,26)=1.04, p=0.32
	M - High	9.4 (4.9)	8.1 (3.6)	8.0 (2.7)	
	F - Low	10.2 (7.7)	10.6 (3.7)	8.4 (3.6)	
	F - High	7.1 (4.1)	6.6 (4.3)	5.9 (4.4)	
		F(d)(2,54)=0.43, p=0.65 F(gd)(2,54)=0.44, p=0.65 F(cd)(2,54)=0.26, p=0.78			F(gcd)(2,54)=0.25, p=0.78
Day 2	M - Low	13.8 (5.2)	14.1 (4.8)	13.5 (6.7)	F(g)(1,26)=0.62. p=0.44 F(c)(1,26)=3.86, p=0.06 F(gc)(1,26)=0.86, p=0.36
	M - High	13.6 (3.4)	14.9 (6.3)	16.1 (6.0)	
	F - Low	13.9 (2.6)	11.5 (1.6)	15.0 (2.9)	
	F - High	18.9 (4.2)	17.6 (5.0)	16.1 (2.7)	
		F(d)(2,54)=0.42, p=0.66 F(gd)(2,54)=1.83, p=0.17 F(cd)(2,54)=0.46, p=0.63			**F(gcd)(2,54)=3.45, p=0.04**

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.23: Cumulative Test Meal Intake - Proportions of All Macronutrients consumed (%kcal) (mean (st.dev.)) and Results of Analysis (mixed ANCOVA) - Study 4

Proportions of Carbohydrate Consumed

Meal	Consumer	Condition			Significance
		W	AS	NS	
Morning	M - Low	37.3 (4.1)	38.3 (4.6)	40.7 (3.0)	F(g)(1,11)=0.59, p=0.46 F(c)(1,11)=0.51, p=0.49 F(gc)(1,11)=0.31, p=0.59
	M - High	38.3 (6.8)	41.4 (3.1)	45.5 (12.6)	
	F - Low	57.3 (37.9)	39.9 (6.3)	47.8 (18.9)	
	F - High	45.0 (10.6)	33.1 (16.1)	51.0 (21.2)	
		F(d)(2,24)=3.21, p=0.06 F(gd)(2,24)=0.26, p=0.77 F(cd)(2,24)=1.40, p=0.27			F(gcd)(2,56)=1.79, p=0.19
+ Lunch	M - Low	47.6 (2.1)	49.5 (3.2)	48.7 (2.2)	F(g)(1,27)=0.00, p=0.95 F(c)(1,27)=0.03, p=0.86 F(gc)(1,27)=0.41, p=0.53
	M - High	51.7 (6.3)	50.2 (3.9)	52.4 (5.9)	
	F - Low	52.5 (5.8)	50.8 (4.8)	51.7 (6.3)	
	F - High	51.5 (5.0)	52.8 (6.0)	54.1 (5.8)	
		F(d)(2,56)=0.83, p=0.44 F(gd)(2,56)=0.04, p=0.96 F(cd)(2,56)=0.70, p=0.50			F(gcd)(2,56)=2.19, p=0.12
+ Afternoon	M - Low	46.5 (2.8)	47.8 (3.6)	47.7 (2.5)	F(g)(1,27)=0.21, p=0.65 F(c)(1,27)=0.08, p=0.79 F(gc)(1,27)=0.40, p=0.53
	M - High	49.5 (5.3)	48.6 (3.5)	49.8 (5.4)	
	F - Low	52.2 (5.7)	49.2 (5.4)	51.6 (5.8)	
	F - High	50.3 (5.5)	51.2 (6.5)	52.2 (5.1)	
		F(d)(2,56)=1.48, p=0.24 F(gd)(2,56)=0.55, p=0.58 F(cd)(2,56)=0.29, p=0.75			F(gcd)(2,56)=2.69, p=0.08
+ Tea	M - Low	45.2 (2.3)	46.1 (2.8)	46.0 (1.4)	F(g)(1,27)=0.01, p=0.94 F(c)(1,27)=0.19, p=0.67 F(gc)(1,27)=1.61, p=0.22
	M - High	48.2 (3.8)	47.9 (2.2)	48.6 (3.5)	
	F - Low	48.4 (2.3)	47.1 (3.5)	48.4 (3.6)	
	F - High	47.5 (3.7)	48.4 (4.3)	48.2 (3.1)	
		F(d)(2,56)=0.76, p=0.47 F(gd)(2,56)=0.13, p=0.88 F(cd)(2,56)=0.17, p=0.84			F(gcd)(2,56)=2.03, p=0.14
+ Evening	M - Low	44.8 (2.4)	45.3 (3.1)	45.3 (1.7)	F(g)(1,27)=0.03, p=0.86 F(c)(1,27)=0.49, p=0.49 F(gc)(1,27)=0.77, p=0.39
	M - High	48.8 (4.4)	47.9 (2.8)	47.0 (4.4)	
	F - Low	47.9 (2.9)	46.5 (3.0)	47.8 (4.7)	
	F - High	47.2 (5.1)	49.8 (4.3)	47.5 (4.6)	
		F(d)(2,56)=0.40, p=0.67 F(gd)(2,56)=0.34, p=0.71 F(cd)(2,56)=1.98, p=0.15			F(gcd)(2,56)=2.81, p=0.07
+ Day 2	M - Low	44.4 (3.6)	45.0 (5.0)	47.3 (4.1)	F(g)(1,26)=1.19, p=0.29 F(c)(1,26)=0.05, p=0.83 F(gc)(1,26)=0.09, p=0.77
	M - High	47.8 (7.7)	46.1 (5.3)	45.4 (6.1)	
	F - Low	49.3 (4.8)	49.3 (3.6)	48.0 (6.0)	
	F - High	48.3 (2.7)	51.7 (6.2)	51.3 (5.6)	
		F(d)(2,54)=0.20, p=0.82 F(gd)(2,54)=1.02, p=0.37 F(cd)(2,54)=0.14, p=0.87			**F(gcd)(2,54)=3.98, p=0.03**

Proportions of Fat consumed

Meal	Consumer	Condition W	AS	NS	Significance
Morning	M - Low	54.6 (4.5)	53.8 (5.1)	51.1 (2.5)	F(g)(1,11)=0.79, p=0.39 F(c)(1,11)=0.88, p=0.37 F(gc)(1,11)=0.65, p=0.44
	M - High	53.9 (7.8)	51.0 (4.7)	45.7 (13.8)	
	F - Low	31.3 (46.3)	51.1 (5.6)	43.6 (21.7)	
	F - High	42.6 (19.5)	50.3 (11.6)	34.4 (30.2)	
		F(d)(2,24)=3.42, p=0.05 F(gd)(2,24)=0.57, p=0.57 F(cd)(2,24)=2.62, p=0.09			F(gcd)(2,24)=2.19, p=0.13
+ Lunch	M - Low	34.2 (5.1)	32.6 (5.0)	33.0 (5.7)	F(g)(1,27)=0.01, p=0.93 F(c)(1,27)=0.12, p=0.74 F(gc)(1,27)=0.03, p=0.87
	M - High	29.1 (7.3)	33.4 (3.5)	30.1 (5.1)	
	F - Low	29.3 (8.2)	33.2 (8.9)	30.2 (6.7)	
	F - High	29.8 (5.9)	27.6 (5.7)	25.8 (5.8)	
		F(d)(2,56)=2.23, p=0.12 F(gd)(2,56)=0.30, p=0.74 F(cd)(2,56)=0.33, p=0.72			**F(gcd)(2,56)=5.15, p=0.01**
+ Afternoon	M - Low	36.6 (7.0)	35.3 (7.0)	35.7 (6.9)	F(g)(1,27)=0.17, p=0.68 F(c)(1,27)=0.06, p=0.82 F(gc)(1,27)=0.02, p=0.88
	M - High	33.1 (7.3)	36.1 (4.0)	34.1 (5.6)	
	F - Low	31.0 (8.6)	35.3 (9.5)	30.6 (6.4)	
	F - High	33.2 (6.9)	31.3 (7.7)	29.8 (6.2)	
		F(d)(2,56)=2.43, p=0.10 F(gd)(2,56)=0.99, p=0.38 F(cd)(2,56)=0.15, p=0.86			**F(gcd)(2,56)=4.47, p=0.02**
+ Tea	M - Low	39.3 (4.5)	38.2 (4.7)	38.4 (4.6)	F(g)(1,27)=0.11, p=0.74 F(c)(1,27)=0.05, p=0.82 F(gc)(1,27)=0.16, p=0.69
	M - High	36.4 (3.9)	37.9 (2.1)	36.6 (3.3)	
	F - Low	36.1 (3.6)	38.1 (4.4)	35.5 (3.3)	
	F - High	37.1 (4.4)	35.4 (4.9)	35.3 (3.9)	
		F(d)(2,56)=2.15, p=0.13 F(gd)(2,56)=0.38, p=0.68 F(cd)(2,56)=0.19, p=0.83			**F(gcd)(2,56)=5.04, p=0.01**
+ Evening	M - Low	40.3 (3.9)	39.6 (4.8)	39.3 (4.7)	F(g)(1,27)=0.08, p=0.78 F(c)(1,27)=0.66, p=0.42 F(gc)(1,27)=0.48, p=0.49
	M - High	36.0 (4.9)	38.3 (2.9)	36.7 (3.4)	
	F - Low	36.7 (4.1)	39.1 (3.6)	37.3 (4.3)	
	F - High	38.1 (5.6)	35.0 (3.9)	37.5 (5.8)	
		F(d)(2,56)=0.11, p=0.89 F(gd)(2,56)=0.70, p=0.50 F(cd)(2,56)=0.91, p=0.41			**F(gcd)(2,56)=6.30, p=0.003**
+ Day 2	M - Low	38.4 (4.5)	39.5 (4.2)	36.0 (4.1)	F(g)(1,26)=3.49. p=0.07 F(c)(1,26)=3.93, p=0.06 F(gc)(1,26)=0.00, p=0.96
	M - High	34.1 (4.2)	37.2 (4.3)	34.8 (3.1)	
	F - Low	34.1 (4.9)	37.4 (4.1)	34.3 (3.1)	
	F - High	34.1 (4.4)	30.6 (2.8)	33.1 (6.8)	
		F(d)(2,54)=2.05, p=0.14 F(gd)(2,54)=1.60, p=0.21 F(cd)(2,54)=2.04, p=0.14			**F(gcd)(2,54)=3.42, p=0.04**

Proportions of Protein Consumed

Meal	Consumer	Condition W	AS	NS	Significance
Morning	M - Low	5.5 (1.0)	5.3 (1.1)	5.4 (1.2)	F(g)(1,11)=0.00, p=0.95 F(c)(1,11)=0.08, p=0.78 F(gc)(1,11)=0.64, p=0.44
	M - High	5.4 (1.0)	5.5 (1.5)	6.4 (2.9)	
	F - Low	8.6 (7.8)	6.9 (1.3)	6.2 (3.7)	
	F - High	10.0 (12.1)	14.7 (23.9)	4.3 (3.8)	
		F(d)(2,56)=0.43, p=0.65 F(gd)(2,56)=1.75, p=0.20 F(cd)(2,56)=1.70, p=0.20			F(gcd)(2,56)=1.08, p=0.36
+ Lunch	M - Low	14.9 (3.8)	14.4 (3.3)	14.9 (3.8)	F(g)(1,27)=0.23, p=0.63 F(c)(1,27)=0.00, p=0.97 F(gc)(1,27)=0.32, p=0.58
	M - High	15.5 (4.4)	13.1 (3.2)	14.0 (3.1)	
	F - Low	15.0 (2.9)	15.2 (3.1)	14.8 (2.8)	
	F - High	15.2 (3.9)	15.9 (3.6)	16.3 (2.9)	
		F(d)(2,56)=0.68, p=0.51 F(gd)(2,56)=2.12, p=0.13 F(cd)(2,56)=0.38, p=0.69			F(gcd)(2,56)=1.39, p=0.26
+ Afternoon	M - Low	13.6 (4.6)	13.5 (4.1)	13.3 (4.5)	F(g)(1,27)=0.13, p=0.72 F(c)(1,27)=0.07, p=0.80 F(gc)(1,27)=0.05, p=0.82
	M - High	13.9 (5.1)	12.1 (3.4)	12.6 (3.5)	
	F - Low	13.5 (2.9)	13.4 (3.1)	14.5 (3.1)	
	F - High	13.0 (2.2)	14.0 (3.2)	14.2 (1.9)	
		F(d)(2,56)=0.53, p=0.59 **F(gd)(2,56)=3.16, p=0.05** F(cd)(2,56)=0.14, p=0.87			F(gcd)(2,56)=1.59, p=0.21
+ Tea	M - Low	13.1 (3.2)	13.1 (3.2)	13.1 (3.6)	F(g)(1,27)=0.58, p=0.45 F(c)(1,27)=0.10, p=0.75 F(gc)(1,27)=0.52, p=0.48
	M - High	12.9 (2.6)	11.7 (2.1)	12.2 (2.4)	
	F - Low	13.2 (1.7)	13.1 (2.2)	13.7 (2.1)	
	F - High	13.1 (1.4)	13.7 (2.3)	14.2 (1.3)	
		F(d)(2,56)=1.15, p=0.32 F(gd)(2,56)=2.82, p=0.07 F(cd)(2,56)=0.08, p=0.93			F(gcd)(2,56)=2.07, p=0.14
+ Evening	M - Low	12.4 (2.3)	12.5 (3.2)	12.8 (3.4)	F(g)(1,27)=0.47, p=0.50 F(c)(1,27)=0.14, p=0.71 F(gc)(1,27)=0.13, p=0.72
	M - High	12.3 (2.0)	11.2 (1.4)	11.5 (2.0)	
	F - Low	12.7 (2.5)	12.4 (2.1)	12.5 (1.8)	
	F - High	11.7 (1.8)	12.2 (2.7)	12.5 (2.1)	
		F(d)(2,56)=0.46, p=0.63 F(gd)(2,56)=0.60, p=0.55 F(cd)(2,56)=0.09, p=0.91			F(gcd)(2,56)=2.53, p=0.09
+ Day 2	M - Low	12.7 (2.8)	13.2 (3.0)	12.9 (3.7)	F(g)(1,26)=0.79, p=0.38 F(c)(1,26)=1.54, p=0.23 F(gc)(1,26)=0.50, p=0.49
	M - High	12.7 (1.9)	12.8 (3.2)	13.5 (3.3)	
	F - Low	13.1 (1.0)	11.9 (0.8)	13.7 (2.0)	
	F - High	14.5 (1.7)	14.5 (3.1)	13.9 (1.8)	
		F(d)(2,54)=0.85, p=0.43 F(gd)(2,54)=0.88, p=0.42 F(cd)(2,54)=0.32, p=0.73			F(gcd)(2,54)=2.66, p=0.08

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(d)= Main Effect of Drink Preload. F(gc) = Gender by Consumer Interaction; F(gd) = Gender by Drink Preload Interaction; F(cd) = Consumer by Drink Preload Interaction; F(gcd) = Gender by Consumer by Drink Preload Interaction.

APPENDIX 8.24: Results of all Covariate Tests in all Subjective ANCOVA Analyses - Study 4

Analyses	All Participants		Female Participants Only	
Covariates	Restraint		Restraint	
	Test t	p	Test t	p
Hunger	-0.49	0.63	-1.22	0.24
Desire to Eat	-0.35	0.73	-1.61	0.13
Fullness	-0.26	0.80	0.26	0.80
Prospective Consumption	0.32	0.75	-1.03	0.32
Thirst	0.44	0.67	-1.63	0.13
Desire to Drink	0.57	0.57	-1.47	0.17

APPENDIX 8.25: Results of all Covariate Tests in all Behavioural ANCOVA Analyses - Study 4

Analyses		All Participants		Female Participants Only	
Covariates		Restraint		Restraint	
		Test t	p	Test t	p
Test Meal	Morning	0.23	0.82	0.82	0.43
Intake -	Lunch	0.35	0.73	-1.02	0.33
Weight	Afternoon	0.29	0.77	0.98	0.35
of Food	Tea	0.18	0.86	-0.52	0.61
Consumed	Evening	-0.75	0.46	0.76	0.46
	Following Day	0.33	0.74	0.29	0.78
	Morning + Lunch	0.37	0.71	-0.55	0.60
	+ Afternoon	0.40	0.69	-0.38	0.71
	+ Tea	0.37	0.72	-0.50	0.62
	+ Evening	0.03	0.98	-0.15	0.89
	+ Following Day	0.21	0.83	0.10	0.93
Test Meal	Morning	0.16	0.87	-1.44	0.17
Intake -	Lunch	0.91	0.37	-0.89	0.39
Energy	Afternoon	0.29	0.78	0.97	0.35
Consumed	Tea	0.59	0.56	-0.12	0.91
	Evening	-0.14	0.89	0.29	0.77
	Following Day	-0.74	0.47	-1.75	0.10
	Morning + Lunch	0.57	0.58	-1.68	0.12
	+ Afternoon	0.51	0.62	-1.03	0.32
	+ Tea	0.63	0.54	-0.73	0.48
	+ Evening	0.38	0.71	-0.36	0.72
	+ Following Day	-0.51	0.96	-1.37	0.20
Total	Lunch	0.57	0.58	-1.68	0.12
Energy	+ Tea	0.63	0.54	-0.73	0.48
Intake	+ Evening	0.38	0.71	-0.36	0.72
	+ Following Day	-0.51	0.96	-1.37	0.20

Results of all Covariate Tests in all Behavioural ANCOVA Analyses - Study 4 continued.

Analyses		All Participants		Female Participants Only	
Covariates		Restraint		Restraint	
		Test t	p	Test t	p
Test Meal	Morning	0.05	0.96	0.65	0.56
Intake -	Lunch	0.91	0.37	0.18	0.89
% Energy	Afternoon	1.07	0.32	1.42	0.39
consumed	Tea	-0.94	0.35	-1.07	0.30
from CHO	Evening	0.20	0.85	1.23	0.24
	Following Day	0.10	0.92	2.01	0.07
	Morning + Lunch	**2.05**	**0.05**	1.78	0.10
	+ Afternoon	1.85	0.08	1.23	0.24
	+ Tea	1.30	0.20	0.65	0.53
	+ Evening	1.24	0.23	1.45	0.17
	+ Following Day	1.37	0.18	**2.27**	**0.04**
Test Meal	Morning	0.01	0.99	-0.65	0.56
Intake -	Lunch	-0.80	0.43	-0.28	0.78
% Energy	Afternoon	-1.11	0.30	-1.45	0.38
consumed	Tea	0.50	0.62	1.03	0.32
from Fat	Evening	1.02	0.32	-0.09	0.93
	Following Day	-0.53	0.60	-1.82	0.09
	Morning + Lunch	-1.97	0.06	**-2.18**	**0.05**
	+ Afternoon	-1.37	0.18	-0.99	0.34
	+ Tea	-1.10	0.28	-0.47	0.65
	+ Evening	-0.58	0.57	-0.72	0.49
	+ Following Day	0.07	0.95	-1.08	0.30
Test Meal	Morning	-1.09	0.30	-0.28	0.80
Intake -	Lunch	-0.74	0.47	-0.20	0.85
% Energy	Afternoon	0.61	0.56	1.94	0.30
consumed	Tea	0.53	0.60	-0.30	0.77
from	Evening	-1.00	0.32	-0.25	0.81
Protein	Following Day	-1.15	0.26	0.98	0.35
	Morning + Lunch	0.33	0.74	1.04	0.32
	+ Afternoon	0.06	0.96	0.06	0.96
	+ Tea	0.06	0.95	-0.21	0.84
	+ Evening	-0.77	0.45	-0.60	0.56
	+ Following Day	-0.77	0.46	-0.22	0.83

APPENDIX 9.1: Recipes and Energy and Macronutrient Content of Sweet and Non-Sweet Lunches used in Study 5.

Lunch	Weight	Energy (kcal.)	CHO (gram.)	Fat (gram.)	Protein (gram.)
SWEET					
Banana + Cream Cheese Sandwiches:					
Thick White Bread	154.0	328.0	70.1	2.3	11.1
Low Fat Cream Cheese	44.0	84.1	1.5	7.0	3.7
Banana	75.6	71.0	17.5	0.2	0.9
Caster Sugar	8.1	32.0	8.5	0.0	0.0
Toffee Popcorn	20.0	77.9	16.2	1.6	0.6
Swiss Roll	39.0	113.6	26.1	0.9	1.9
Total	340.7	706.6	139.9	12.0	18.2
(% energy)			(74.2%)	(15.3%)	(10.3%)
NON-SWEET					
Cottage Cheese + Lettuce Sandwiches:					
Thick White Bread	180.0	391.8	81.9	2.7	15.1
Low Fat Cottage Cheese	40.0	37.3	1.4	1.6	4.4
Lettuce	35.0	4.4	0.6	0.1	0.3
Low Fat Crisps	30.8	117.4	20.8	3.6	1.7
Water Biscuits	32.4	125.9	25.3	2.4	2.3
Low Fat Cream Cheese	16.8	32.2	0.6	2.7	1.4
Total	335.0	709.0	130.6	13.1	24.2
(% energy)			(69.1%)	(16.6%)	(13.7%)

The values provided in this table are for male participants.
For female participants 75% of all values were used.

APPENDIX 9.2: Energy and Macronutrient Content of all Test Foods used in Study 5.

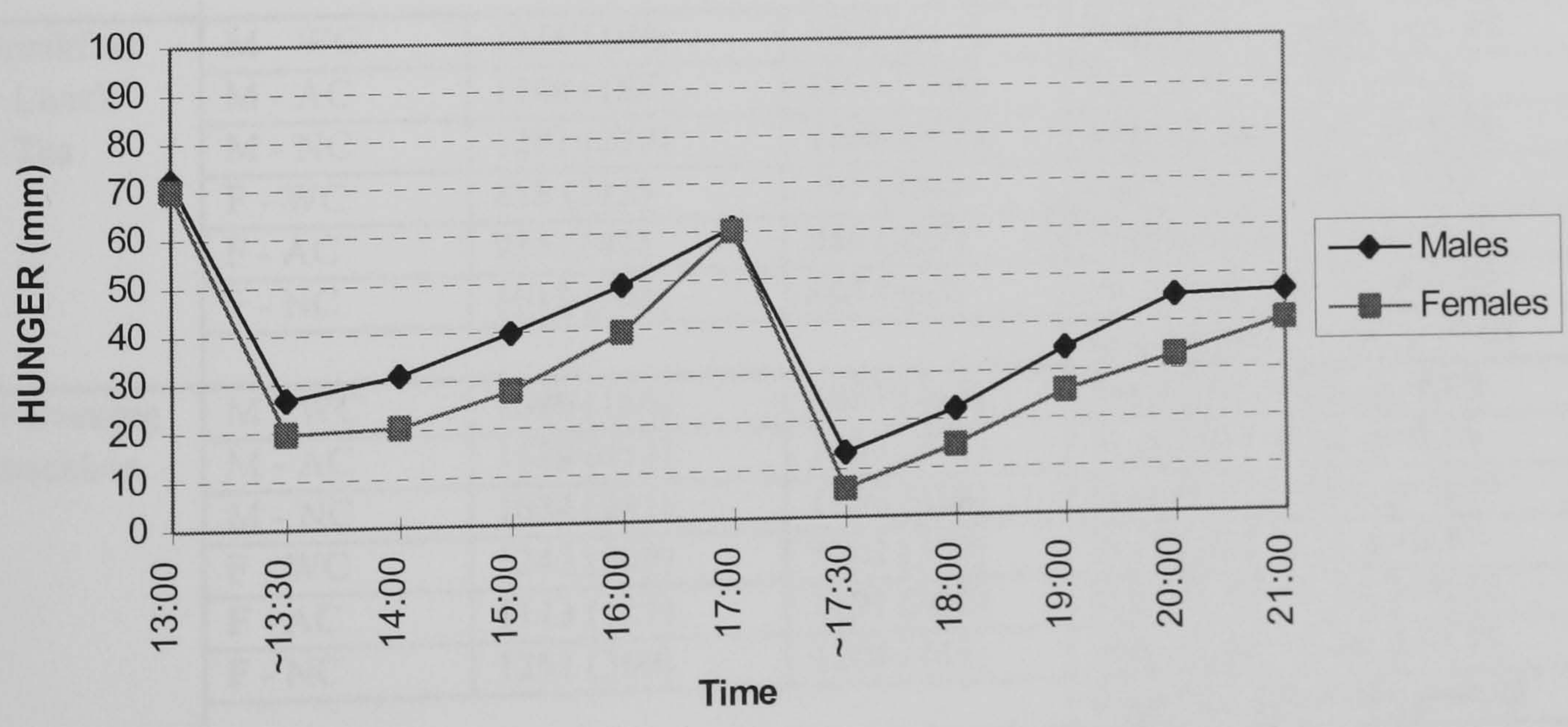
Foods - Tea	Energy (kcal/g)	Carbohydrate (g/g)	Fat (g/g)	Protein (g/g)
Vegetable Lasagne	1.04	0.092	0.061	0.038
Peas	0.62	0.090	0.007	0.049
Digestive Biscuits	4.96	0.676	0.221	0.066
Apples	0.45	0.115	0.001	0.003
Water	0	0	0	0
Foods - Snackbox	**Energy (kcal/g or kcal/ptn)**	**Carbohydrate (g/g or g/ptn)**	**Fat (g/g or g/ptn)**	**Protein (g/g or g/ptn)**
Bread Rolls (brown)	2.43	0.480	0.020	0.090
Margarine (ptn)	63.5	0.10	7.00	0.02
Cheese (ptn)	82.4	0.02	6.88	5.10
Jam (ptn)	52.2	13.80	0	0.12
Crisps (ptn)	149.0	12.40	10.30	1.60
Biscuits (ptn)	151.5	18.50	7.80	1.82
Yoghurts (ptn)	137.0	21.97	2.63	7.13
Apples	0.45	0.115	0.001	0.003

APPENDIX 9.3: Ratings of Preload Lunches - means, (standard deviations) and the results of all analyses (ANOVA), in Study 5.

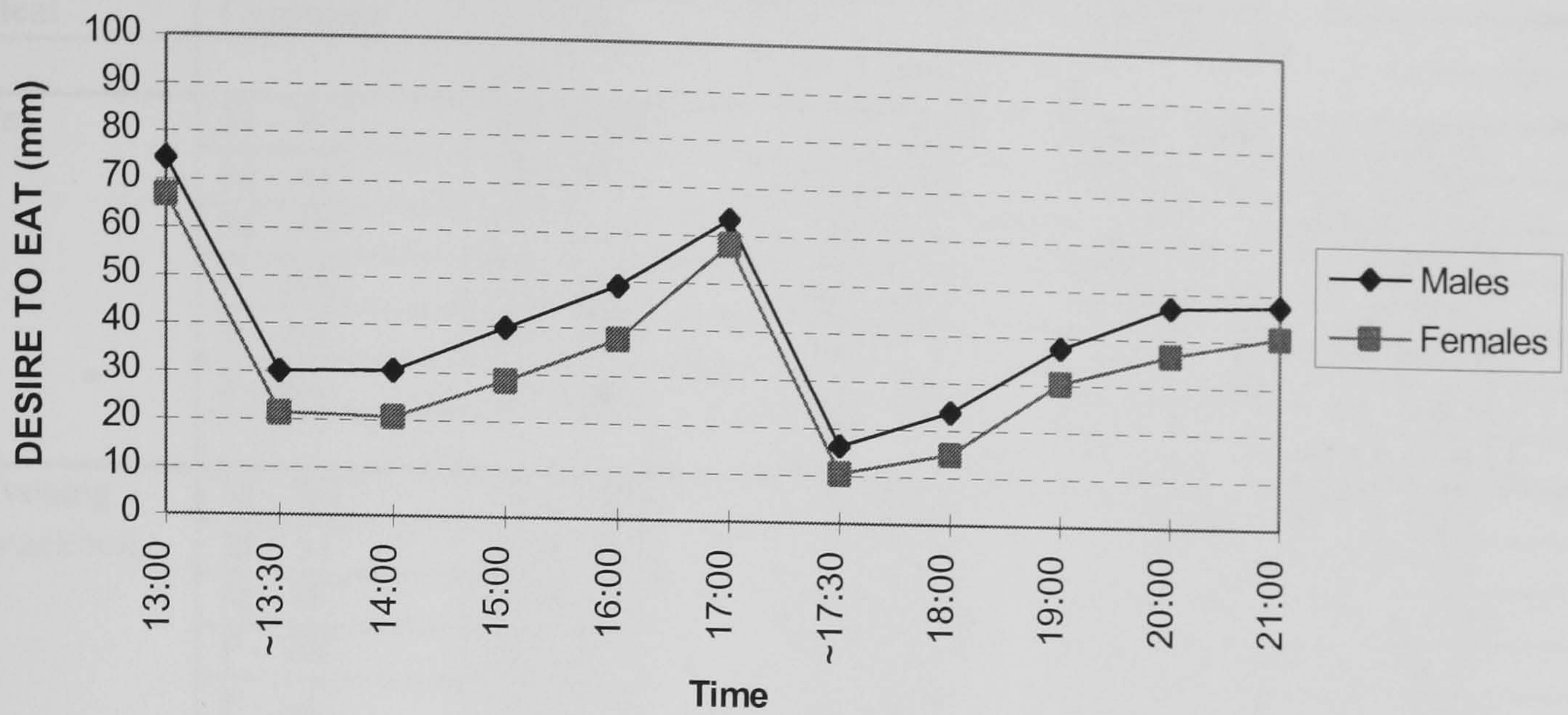
Rating	Consumer Group	Preload Sweet	Non-sweet	Significance
Pleasantness	M - WC	68 (14)	69 (12)	**F(c)(5,42)=3.09, p=0.02**
	M - AC	55 (20)	43 (15)	F(p)(1,42)=0.21, p=0.65
	M - NC	46 (20)	61 (19)	F(cp)(5,42)=1.41, p=0.24
	F - WC	63 (29)	60 (18)	
	F - AC	44 (19)	60 (27)	
	F - NC	71 (7)	65 (21)	
Tastiness	M - WC	71 (12)	59 (12)	**F(c)(5,42)=2.64, p=0.04**
	M - AC	66 (11)	35 (21)	**F(p)(1,42)=6.16, p=0.02**
	M - NC	47 (18)	51 (21)	F(cp)(5,42)=1.76, p=0.14
	F - WC	68 (29)	50 (26)	
	F - AC	48 (17)	54 (27)	
	F - NC	72 (10)	59 (22)	
Sweetness	M - WC	87 (8)	18 (17)	F(c)(5,42)=3.53, p=0.08
	M - AC	91 (8)	15 (21)	**F(p)(1,42)=752.72, p<0.001**
	M - NC	86 (9)	14 (11)	F(cp)(5,42)=0.26, p=0.93
	F - WC	81 (9)	11 (8)	
	F - AC	80 (13)	11 (8)	
	F - NC	92 (6)	14 (10)	
Saltiness	M - WC	17 (9)	73 (14)	F(c)(5,42)=0.65, p=0.66
	M - AC	14 (15)	75 (24)	**F(p)(1,42)=305.83, p<0.001**
	M - NC	26 (18)	76 (10)	F(cp)(5,42)=0.35, p=0.88
	F - WC	10 (24)	69 (23)	
	F - AC	15 (14)	79 (7)	
	F - NC	19 (17)	73 (20)	

F(c) = Main Effect of Consumer; F(p) = Main Effect of Preload Lunch.
F(cp) = Consumer by Preload Interaction.

APPENDIX 9.4: Temporal Profile for Subjective Measures of HUNGER - All Participants - Gender by Time - Study 5



APPENDIX 9.5: Temporal Profile for Subjective Measures of DESIRE TO EAT - All Participants - Gender by Time - Study 5



APPENDIX 9.6: Test Meal Intake - Weight Consumed (gram.) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 5

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Tea	M - WC	897 (203)	1010 (169)	**F(g)(1,41)=5.11, p=0.03**
	M - AC	803 (187)	713 (228)	F(c)(2,41)=0.43, p=0.65
	M - NC	950 (239)	892 (256)	F(gc)(2,41)=1.10, p=0.34
	F - WC	628 (196)	546 (187)	**F(p)(1,42)=3.99, p=0.052**
	F - AC	677 (141)	697 (157)	F(gp)(1,42)=1.80, p=0.19
	F - NC	731 (208)	614 (158)	F(cp)(2,42)=2.82, p=0.07
				F(gcp)(2,42)=6.14, p=0.005
Evening Snackbox	M - WC	399 (127)	391 (255)	F(g)(1,41)=0.52, p=0.48
	M - AC	385 (320)	318 (195)	F(c)(2,41)=1.30, p=0.29
	M - NC	392 (245)	382 (238)	F(gc)(2,41)=1.04, p=0.36
	F - WC	385 (251)	311 (227)	F(p)(1,42)=0.75, p=0.39
	F - AC	178 (76)	215 (153)	F(gp)(1,42)=0.06, p=0.81
	F - NC	233 (115)	223 (96)	F(cp)(2,42)=0.14, p=0.87
				F(gcp)(2,42)=0.92, p=0.41
Breakfast + Lunch + Tea	M - WC	1246 (199)	1429 (171)	**F(g)(1,41)=14.94, p<0.001**
	M - AC	1144 (188)	1083 (284)	F(c)(2,41)=0.48, p=0.62
	M - NC	1291 (239)	1268 (267)	F(gc)(2,41)=1.47, p=0.24
	F - WC	858 (212)	797 (184)	F(p)(1,42)=0.40, p=0.53
	F - AC	935 (141)	949 (202)	F(gp)(1,42)=3.41, p=0.07
	F - NC	1018 (268)	865 (402)	F(cp)(2,42)=2.53, p=0.09
				F(gcp)(2,42)=2.98, p=0.06
+ Evening Snackbox	M - WC	1646 (186)	1820 (240)	**F(g)(1,41)=5.31, p=0.03**
	M - AC	1529 (453)	1401 (375)	F(c)(2,41)=0.63, p=0.54
	M - NC	1684 (441)	1650 (419)	F(gc)(2,41)=0.01, p=0.99
	F - WC	1243 (369)	1102 (360)	F(p)(1,42)=0.21, p=0.65
	F - AC	1113 (167)	1191 (302)	F(gp)(1,42)=0.34, p=0.56
	F - NC	1251 (360)	1204 (441)	F(cp)(2,42)=0.24, p=0.79
				F(gcp)(2,42)=4.66, p=0.02

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(p) = Main Effect of Preload Lunch. F(gc) = Gender by Consumer Interaction; F(gp) = Gender by Preload Lunch Interaction; F(cp) = Consumer by Preload Interaction; F(gcp) = Gender by Consumer by Preload Interaction.

APPENDIX 9.7: Test Meal Intake - Energy Consumed (kcal.) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 5

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Tea	M - WC	924 (266)	1018 (229)	F(g)(1,41)=2.29, p=0.14
	M - AC	837 (202)	741 (259)	F(c)(2,41)=0.88, p=0.42
	M - NC	956 (435)	838 (279)	F(gc)(2,41)=0.24, p=0.79
	F - WC	689 (219)	637 (255)	F(p)(1,42)=2.51, p=0.12
	F - AC	684 (126)	701 (152)	F(gp)(1,42)=0.00, p=0.99
	F - NC	718 (182)	632 (189)	F(cp)(2,42)=1.94, p=0.16
				F(gcp)(2,42)=2.24, p=0.12
Evening Snackbox	M - WC	1010 (404)	1080 (569)	F(g)(1,41)=0.21, p=0.65
	M - AC	1015 (673)	970 (476)	F(c)(2,41)=0.55, p=0.58
	M - NC	1198 (686)	1000 (466)	F(gc)(2,41)=1.25, p=0.30
	F - WC	986 (473)	922 (507)	F(p)(1,42)=0.59, p=0.45
	F - AC	618 (277)	641 (307)	F(gp)(1,42)=0.02, p=0.90
	F - NC	849 (295)	767 (272)	F(cp)(2,42)=0.51, p=0.61
				F(gcp)(2,42)=0.36, p=0.70
Breakfast + Lunch + Tea	M - WC	1662 (256)	1733 (219)	**F(g)(1,41)=10.60, p=0.002**
	M - AC	1550 (201)	1466 (265)	F(c)(2,41)=0.60, p=0.56
	M - NC	1663 (435)	1580 (264)	F(gc)(2,41)=0.25, p=0.78
	F - WC	1236 (240)	1181 (255)	F(p)(1,42)=0.38, p=0.54
	F - AC	1222 (126)	1301(252)	F(gp)(1,42)=0.23, p=0.64
	F - NC	1258 (204)	1222 (232)	F(cp)(2,42)=0.52, p=0.60
				F(gcp)(2,42)=2.08, p=0.14
+ Evening Snackbox	M - WC	2671 (384)	2813 (654)	F(g)(1,41)=3.06, p=0.09
	M - AC	2564 (721)	2436 (550)	F(c)(2,41)=0.84, p=0.44
	M - NC	2861 (987)	2580 (661)	F(gc)(2,41)=0.46, p=0.63
	F - WC	2222 (587)	2103 (651)	F(p)(1,42)=0.98, p=0.33
	F - AC	1840 (310)	1943 (483)	F(gp)(1,42)=0.11, p=0.75
	F - NC	2107 (405)	1989 (415)	F(cp)(2,42)=0.97, p=0.39
				F(gcp)(2,42)=1.29, p=0.29

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(p) = Main Effect of Preload Lunch. F(gc) = Gender by Consumer Interaction; F(gp) = Gender by Preload Lunch Interaction; F(cp) = Consumer by Preload Interaction; F(gcp) = Gender by Consumer by Preload Interaction.

APPENDIX 9.8: Test Meal Intake - Proportions of All Macronutrients Consumed (%kcal.) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 5

Proportions of Carbohydrate Consumed

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Tea	M - WC	41.5 (3.0)	41.4 (3.0)	**F(g)(1,41)=9.85, p=0.003**
	M - AC	42.1 (2.7)	40.6 (4.7)	F(c)(2,41)=1.32, p=0.28
	M - NC	41.4 (2.9)	41.8 (3.5)	F(gc)(2,41)=2.15, p=0.13
	F - WC	46.2 (4.8)	46.4 (4.0)	F(p)(1,42)=0.07, p=0.79
	F - AC	42.8 (1.5)	43.3 (3.1)	F(gp)(1,42)=1.51, p=0.23
	F - NC	42.7 (3.2)	43.8 (2.0)	F(cp)(2,42)=0.82, p=0.45
				F(gcp)(2,42)=0.36, p=0.70
Evening Snackbox	M - WC	44.1 (4.1)	45.9 (6.6)	F(g)(1,41)=0.54, p=0.47
	M - AC	40.1 (10.6)	42.5 (8.3)	F(c)(2,41)=1.50, p=0.24
	M - NC	46.8 (9.6)	48.9 (10.4)	F(gc)(2,41)=0.20, p=0.82
	F - WC	49.8 (5.6)	45.3 (14.3)	F(p)(1,42)=0.00, p=0.98
	F - AC	45.8 (6.9)	44.9 (6.3)	F(gp)(1,42)=2.80, p=0.10
	F - NC	49.4 (6.3)	48.4 (6.9)	F(cp)(2,42)=0.27, p=0.77
				F(gcp)(2,42)=0.17, p=0.84
Breakfast + Lunch + Tea	M - WC	57.9 (1.4)	55.5 (1.7)	**F(g)(1,41)=4.91, p=0.03**
	M - AC	58.0 (1.5)	54.9 (2.5)	F(c)(2,41)=1.08, p=0.35
	M - NC	57.8 (1.5)	56.3 (2.1)	F(gc)(2,41)=1.06, p=0.36
	F - WC	60.5 (2.5)	58.1 (2.2)	**F(p)(1,42)=45.51, p<0.001**
	F - AC	58.8 (0.7)	56.1 (3.9)	F(gp)(1,42)=0.03, p=0.87
	F - NC	58.7 (1.9)	57.1 (1.8)	F(cp)(2,42)=1.39, p=0.26
				F(gcp)(2,42)=0.05, p=0.95
+ Evening Snackbox	M - WC	58.4 (1.2)	56.6 (1.9)	F(g)(1,41)=2.49, p=0.12
	M - AC	57.8 (2.8)	55.4 (2.6)	F(c)(2,41)=1.18, p=0.32
	M - NC	58.7 (2.8)	57.6 (3.2)	F(gc)(2,41)=0.13, p=0.88
	F - WC	61.3 (2.0)	57.5 (5.1)	**F(p)(1,42)=34.76, p<0.001**
	F - AC	59.3 (1.8)	56.5 (3.1)	F(gp)(1,42)=2.44, p=0.13
	F - NC	60.3 (2.2)	58.0 (2.1)	F(cp)(2,42)=0.64, p=0.53
				F(gcp)(2,42)=0.38, p=0.68

Proportions of Fat Consumed

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Tea	M - WC	43.9 (2.4)	43.8 (2.8)	**F(g)(1,41)=18.54, p<0.001**
	M - AC	43.4 (2.8)	44.5 (3.6)	F(c)(2,41)=0.24, p=0.79
	M - NC	42.7 (1.5)	41.9 (2.6)	F(gc)(2,41)=2.29, p=0.12
	F - WC	38.6 (3.6)	38.6 (2.7)	F(p)(1,42)=0.06, p=0.81
	F - AC	40.3 (2.8)	40.5 (3.2)	F(gp)(1,42)=0.08, p=0.77
	F - NC	40.9 (3.4)	40.2 (1.9)	F(cp)(2,42)=1.34, p=0.27
				F(gcp)(2,42)=0.19, p=0.82
Evening Snackbox	M - WC	42.6 (4.9)	42.6 (6.9)	F(g)(1,41)=0.56, p=0.46
	M - AC	34.7 (17.6)	37.7 (15.4)	F(c)(2,41)=0.11, p=0.89
	M - NC	37.1 (10.5)	25.7 (10.2)	F(gc)(2,41)=1.18, p=0.32
	F - WC	34.8 (7.9)	36.4 (9.4)	F(p)(1,42)=0.10, p=0.75
	F - AC	41.6 (5.1)	41.5 (7.1)	F(gp)(1,42)=0.02, p=0.88
	F - NC	41.2 (5.8)	40.2 (9.1)	F(cp)(2,42)=0.45, p=0.64
				F(gcp)(2,42)=0.34, p=0.71

Test Meal Intake - Approximate Proportions of All Macronutrients Consumed (%kcal.) - means, (standard deviations) and the results of all analyses (mixed ANCOVA) - Study 5 - Proportions of Fat Consumed continued.

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Breakfast + Lunch + Tea	M - WC	29.6 (1.2)	30.0 (1.4)	**F(g)(1,41)=7.26, p=0.01**
	M - AC	29.6 (1.6)	30.5 (1.8)	F(c)(2,41)=1.33, p=0.28
	M - NC	29.0 (0.7)	28.4 (1.9)	F(gc)(2,41)=1.40, p=0.26
	F - WC	26.7 (1.6)	27.3 (1.7)	F(p)(1,42)=2.62, p=0.11
	F - AC	27.6 (1.3)	29.0 (4.1)	F(gp)(1,42)=0.65, p=0.43
	F - NC	27.9 (1.8)	28.1 (1.3)	F(cp)(2,42)=1.78, p=0.18
				F(gcp)(2,42)=0.07, p=0.93
+ Evening Snackbox	M - WC	29.5 (1.4)	29.6 (1.8)	F(g)(1,41)=0.18, p=0.67
	M - AC	27.6 (3.9)	28.7 (3.8)	F(c)(2,41)=0.43, p=0.65
	M - NC	27.5 (3.4)	27.2 (2.9)	F(gc)(2,41)=2.35, p=0.11
	F - WC	25.5 (2.4)	26.6 (3.0)	F(p)(1,42)=1.95, p=0.17
	F - AC	28.0 (1.7)	28.9 (3.2)	F(gp)(1,42)=0.27, p=0.61
	F - NC	28.0 (2.1)	28.3 (2.1)	F(cp)(2,42)=0.55, p=0.58
				F(gcp)(2,42)=0.20, p=0.82

Proportions of Protein Consumed

Meal	Consumer	Preload		Significance
		Sweet	Non-sweet	
Tea	M - WC	14.1 (1.3)	14.5 (1.5)	F(g)(1,41)=0.03, p=0.87
	M - AC	13.9 (1.5)	14.6 (2.4)	F(c)(2,41)=1.96, p=0.15
	M - NC	15.6 (2.5)	15.9 (2.4)	F(gc)(2,41)=1.03, p=0.37
	F - WC	14.1 (4.1)	13.7 (3.7)	F(p)(1,42)=0.01, p=0.93
	F - AC	16.1 (1.6)	15.5 (1.7)	F(gp)(1,42)=3.12, p=0.08
	F - NC	15.8 (1.4)	15.3 (1.4)	F(cp)(2,42)=0.02, p=0.99
				F(gcp)(2,42)=0.10, p=0.90
Evening Snackbox	M - WC	10.8 (1.7)	9.2 (3.2)	F(g)(1,41)=0.23, p=0.64
	M - AC	8.9 (2.5)	8.5 (3.3)	F(c)(2,41)=1.32, p=0.28
	M - NC	8.9 (3.2)	9.6 (3.5)	F(gc)(2,41)=0.77, p=0.47
	F - WC	9.6 (2.7)	10.4 (2.6)	F(p)(1,42)=1.16, p=0.29
	F - AC	9.4 (3.6)	10.8 (3.6)	F(gp)(1,42)=3.72, p=0.06
	F - NC	7.0 (1.8)	9.1 (4.1)	F(cp)(2,42)=1.14, p=0.33
				F(gcp)(2,42)=0.08, p=0.92
Breakfast + Lunch + Tea	M - WC	12.2 (0.6)	14.1 (0.8)	F(g)(1,41)=0.02, p=0.89
	M - AC	12.1 (0.8)	14.1 (1.2)	F(c)(2,41)=2.02, p=0.15
	M - NC	12.9 (1.2)	14.8 (1.2)	F(gc)(2,41)=1.00, p=0.38
	F - WC	12.1 (2.1)	13.7 (1.8)	**F(p)(1,42)=121.23, p<0.001**
	F - AC	13.2 (0.9)	14.3 (1.0)	F(gp)(1,42)=3.42, p=0.07
	F - NC	13.0 (0.8)	14.4 (0.9)	F(cp)(2,42)=0.05, p=0.95
				F(gcp)(2,42)=0.31, p=0.73
+ Evening Snackbox	M - WC	11.4 (0.8)	12.8 (0.8)	F(g)(1,41)=0.02, p=0.89
	M - AC	10.9 (0.2)	12.5 (0.7)	F(c)(2,41)=0.07, p=0.94
	M - NC	11.3 (1.1)	13.3 (1.1)	**F(gc)(2,41)=3.85, p=0.03**
	F - WC	10.8 (1.2)	12.7 (1.2)	**F(p)(1,42)=234.00, p<0.001**
	F - AC	11.7 (0.9)	13.5 (0.8)	F(gp)(1,42)=0.69, p=0.41
	F - NC	10.7 (0.3)	12.7 (0.8)	F(cp)(2,42)=0.57, p=0.57
				F(gcp)(2,42)=0.20, p=0.82

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(p) = Main Effect of Preload Lunch. F(gc) = Gender by Consumer Interaction; F(gp) = Gender by Preload Lunch Interaction; F(cp) = Consumer by Preload Interaction; F(gcp) = Gender by Consumer by Preload Interaction.

APPENDIX 9.9: Results and Significance of all Covariate Tests in All ANCOVA Analyses - Study 5 - Subjective Measures

Analyses - All Participants						
Covariates	B.M.I.		Restraint		Tastiness	
	Test t	p	Test t	p	Test t	p
Hunger	-0.47	0.64	-0.68	0.51	-0.04	0.97
Desire to Eat	-0.45	0.66	-0.57	0.57	-0.58	0.57
Fullness	0.44	0.66	1.76	0.09	-0.16	0.87
Prospective Consumption	0.27	0.79	-1.43	0.16	-0.87	0.39
Thirst	-0.07	0.95	1.02	0.31	0.71	0.48
Desire to Drink	-0.11	0.91	0.89	0.38	0.58	0.56
Appetite for S'g Sweet	-1.25	0.22	0.63	0.54	1.33	0.19
Appetite for S'g Savoury	-0.66	0.51	-0.19	0.85	-1.47	0.15
Appetite for a Meal	0.69	0.49	-0.85	0.40	-0.98	0.33
Analyses - Male Participants						
Covariates	B.M.I.		Restraint		Tastiness	
	Test t	p	Test t	p	Test t	p
Hunger	-1.16	0.26	-1.36	0.19	-0.13	0.90
Desire to Eat	-1.69	0.11	-0.93	0.37	0.96	0.35
Fullness	1.19	0.25	0.28	0.78	-1.33	0.20
Prospective Consumption	-0.86	0.40	-1.25	0.23	0.26	0.80
Thirst	-1.46	0.16	-0.97	0.34	0.74	0.47
Desire to Drink	-1.48	0.16	-1.02	0.32	0.68	0.51
Appetite for S'g Sweet	-0.38	0.71	0.60	0.55	1.07	0.30
Appetite for S'g Savoury	-1.28	0.22	-0.77	0.49	-0.07	0.94
Appetite for a Meal	-0.39	0.70	-1.13	0.27	-0.66	0.52

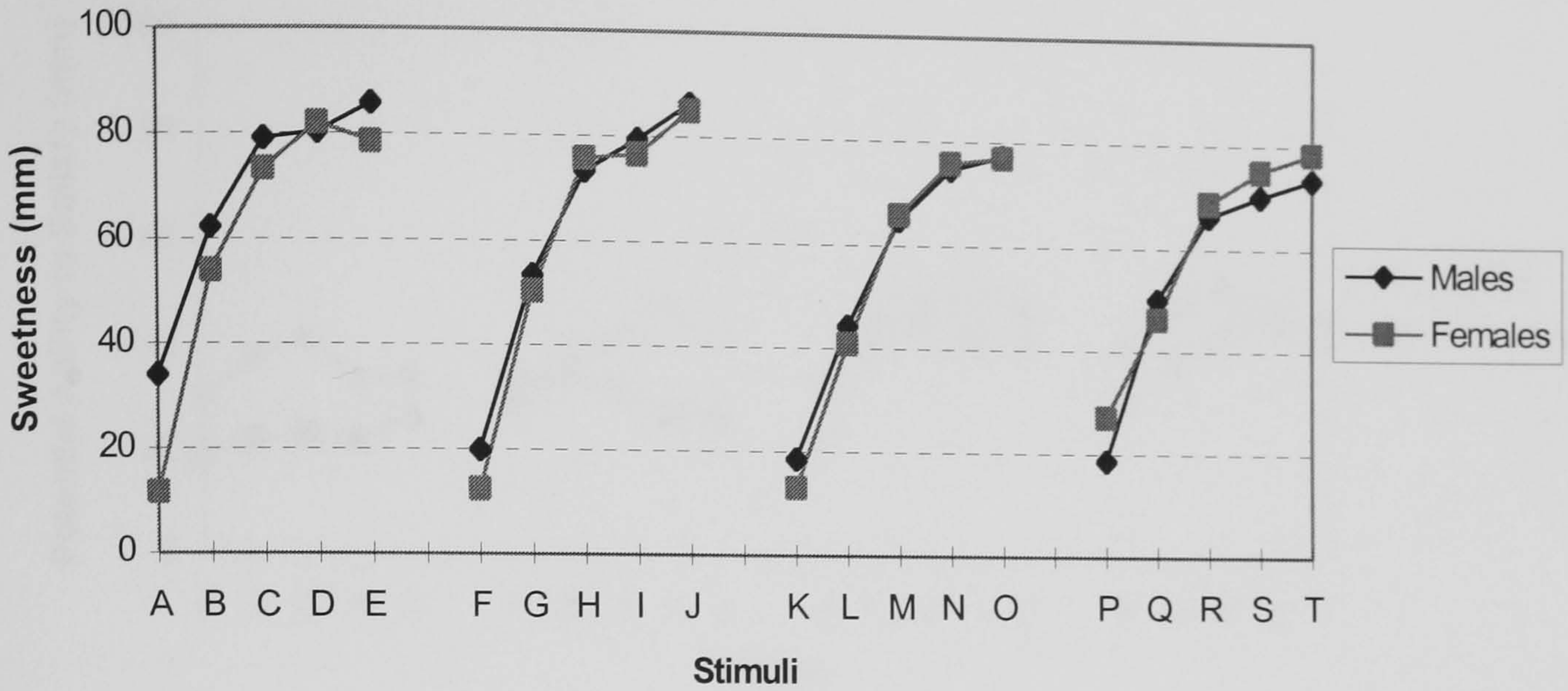
APPENDIX 9.10: Results and Significance of all Covariate Tests in All ANCOVA Analyses - Study 5 - Behavioural Measures

Analyses - All Participants							
Covariates		B.M.I.		Restraint		Tastiness	
		Test t	p	Test t	p	Test t	p
Weight of	Tea	**2.56**	**0.01**	-1.13	0.27	0.90	0.37
Food	Evening	1.22	0.23	-1.13	0.27	1.77	0.09
Consumed	B + L + T	-1.83	0.08	-1.24	0.22	1.11	0.27
	+ Evening	1.89	0.07	-1.46	0.15	1.74	0.09
Energy	Tea	**2.38**	**0.02**	-0.88	0.38	1.53	0.14
Consumed	Evening	1.43	0.16	-1.41	0.17	0.48	0.63
	B + L + T	**2.27**	**0.03**	-1.16	0.25	1.44	0.16
	+ Evening	-2.10	0.04	-1.62	0.11	0.99	0.33
Energy	Tea	-0.12	0.77	-1.08	0.29	**2.84**	**0.01**
Consumed	Evening	-0.62	0.54	0.24	0.82	0.72	0.48
from CHO	B + L + T	-0.68	0.50	0.05	0.96	**2.71**	**0.01**
	+ Evening	-0.46	0.65	0.12	0.90	1.67	0.10
Energy	Tea	-0.37	0.71	0.94	0.32	-0.96	0.33
Consumed	Evening	-0.48	0.63	-0.62	0.54	**2.50**	**0.02**
from fat	B + L + T	0.15	0.88	-0.45	0.65	-1.35	0.19
	+ Evening	-0.38	0.71	-0.55	0.59	1.82	0.08
Energy	Tea	0.87	0.39	0.17	0.87	**-3.25**	**0.002**
Consumed	Evening	0.72	0.48	-0.31	0.76	1.24	0.22
from	B + L + T	0.77	0.44	0.45	0.66	**-2.75**	**0.01**
Protein	+ Evening	0.70	0.49	0.37	0.71	-0.51	0.62

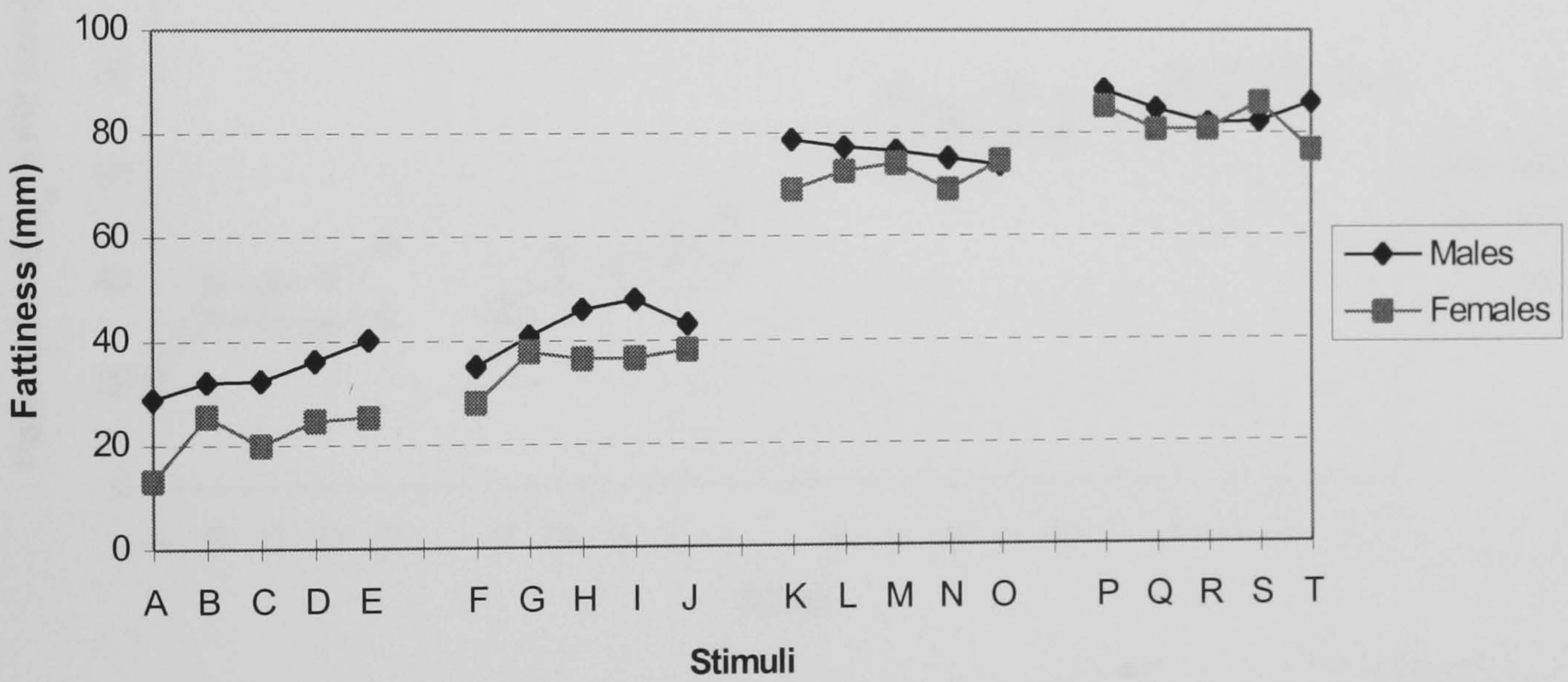
Results and Significance of all Covariate Tests in All ANCOVA Analyses - Study 5 - Behavioural Measures, continued

Analyses - Male Participants							
Covariates		B.M.I.		Restraint		Tastiness	
		Test t	p	Test t	p	Test t	p
Weight of	Tea	**2.53**	**0.02**	-1.48	0.16	1.17	0.26
Food	Evening	1.24	0.23	-0.51	0.62	1.48	0.16
Consumed	B + L + T	**2.09**	**0.05**	-1.43	0.17	1.59	0.13
	+ Evening	**2.15**	**0.05**	-1.22	0.24	2.01	0.06
Energy	Tea	**2.51**	**0.02**	-1.38	0.18	-1.12	0.28
Consumed	Evening	0.94	0.36	-0.31	0.76	0.77	0.45
	B + L + T	**2.52**	**0.02**	-1.80	0.13	1.21	0.24
	+ Evening	1.78	0.09	-0.88	0.39	1.14	0.27
Energy	Tea	-1.16	0.26	0.41	0.68	**2.15**	**0.05**
Consumed	Evening	-1.14	0.27	0.11	0.91	1.19	0.25
from CHO	B + L + T	-1.99	0.06	0.68	0.51	**2.86**	**0.01**
	+ Evening	-1.42	0.17	0.29	0.78	**2.26**	**0.04**
Energy	Tea	0.99	0.33	-0.77	0.45	-1.30	0.21
Consumed	Evening	-0.90	0.38	-0.72	0.48	**2.12**	**0.05**
from fat	B + L + T	1.90	0.07	-1.14	0.27	-2.03	0.06
	+ Evening	0.41	0.69	0.94	0.36	1.55	0.14
Energy	Tea	0.54	0.60	0.30	0.77	-2.04	0.06
Consumed	Evening	0.51	0.62	0.34	0.74	1.82	0.09
from	B + L + T	0.43	0.67	0.42	0.68	1.77	0.09
Protein	+ Evening	0.47	0.65	0.22	0.83	-0.01	0.99

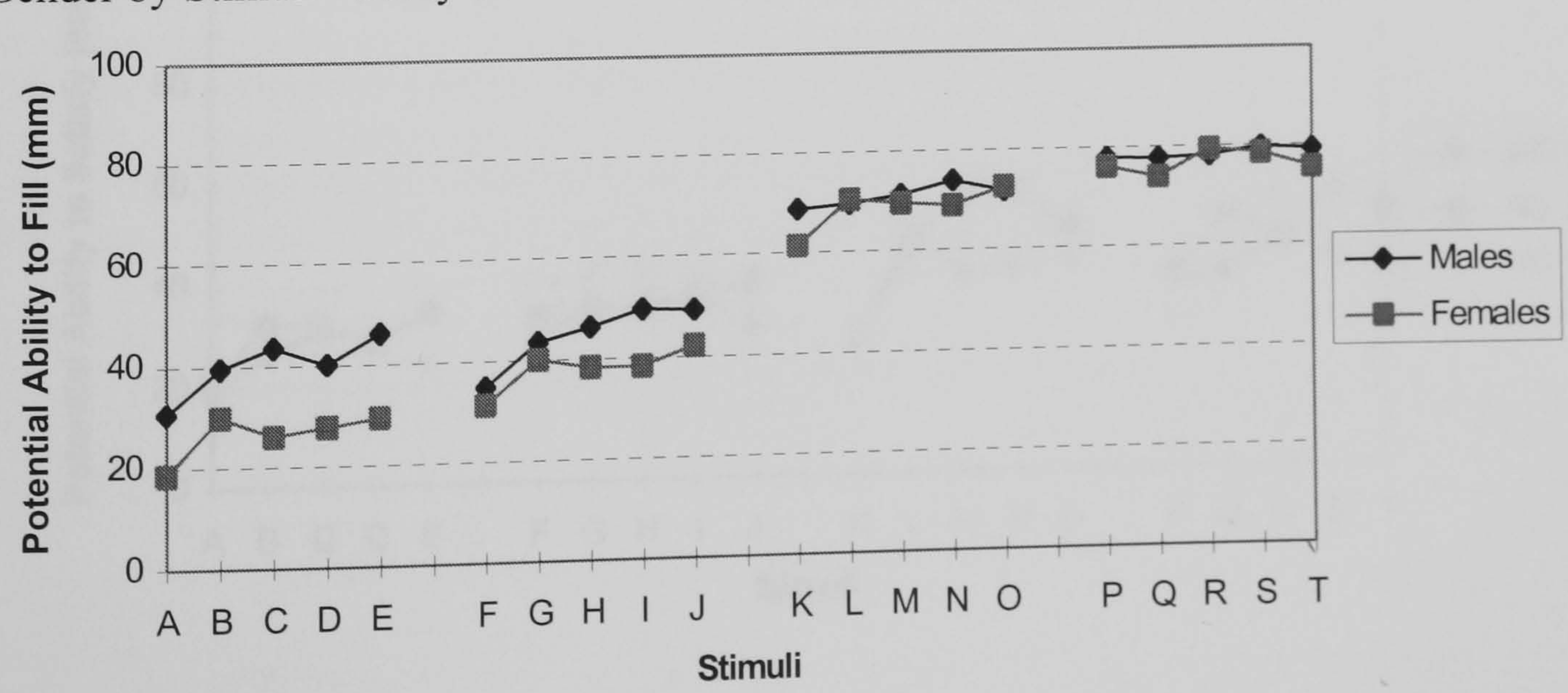
APPENDIX 10.1: Profile of Sweetness for all Stimuli for All Participants - Gender by Stimuli - Study 6



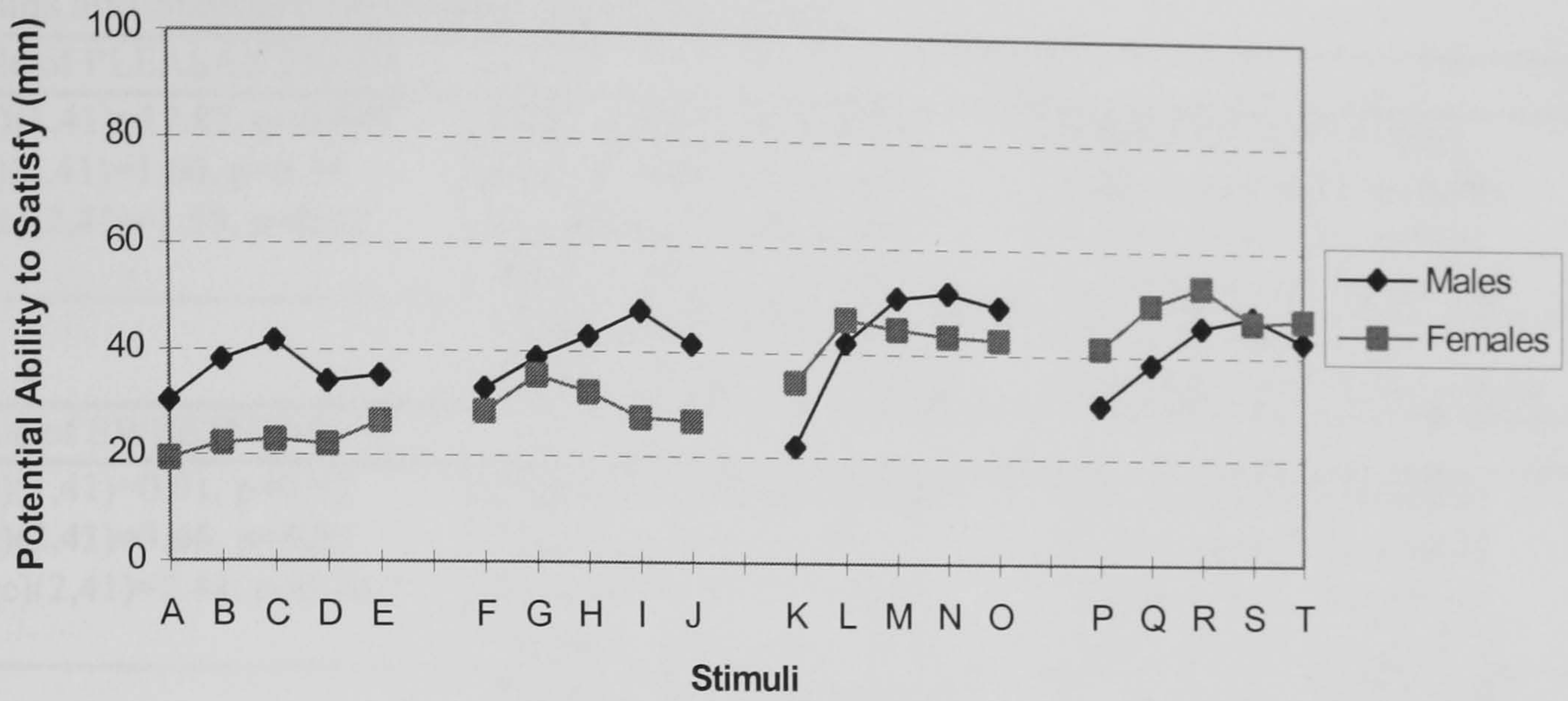
APPENDIX 10.2: Profile of Fattiness for all Stimuli for All Participants - Gender by Stimuli - Study 6



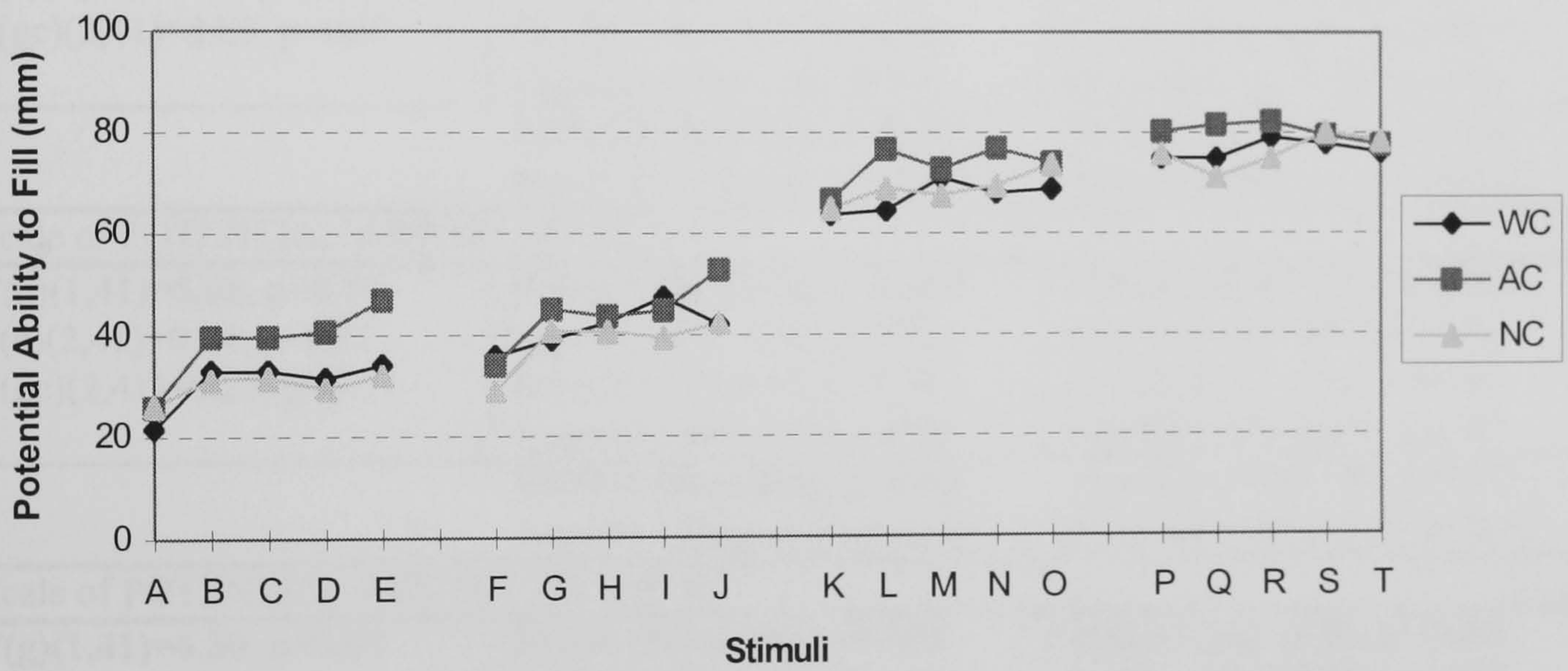
APPENDIX 10.3: Profile of Potential Ability to Fill for all Stimuli for All Participants - Gender by Stimuli - Study 6



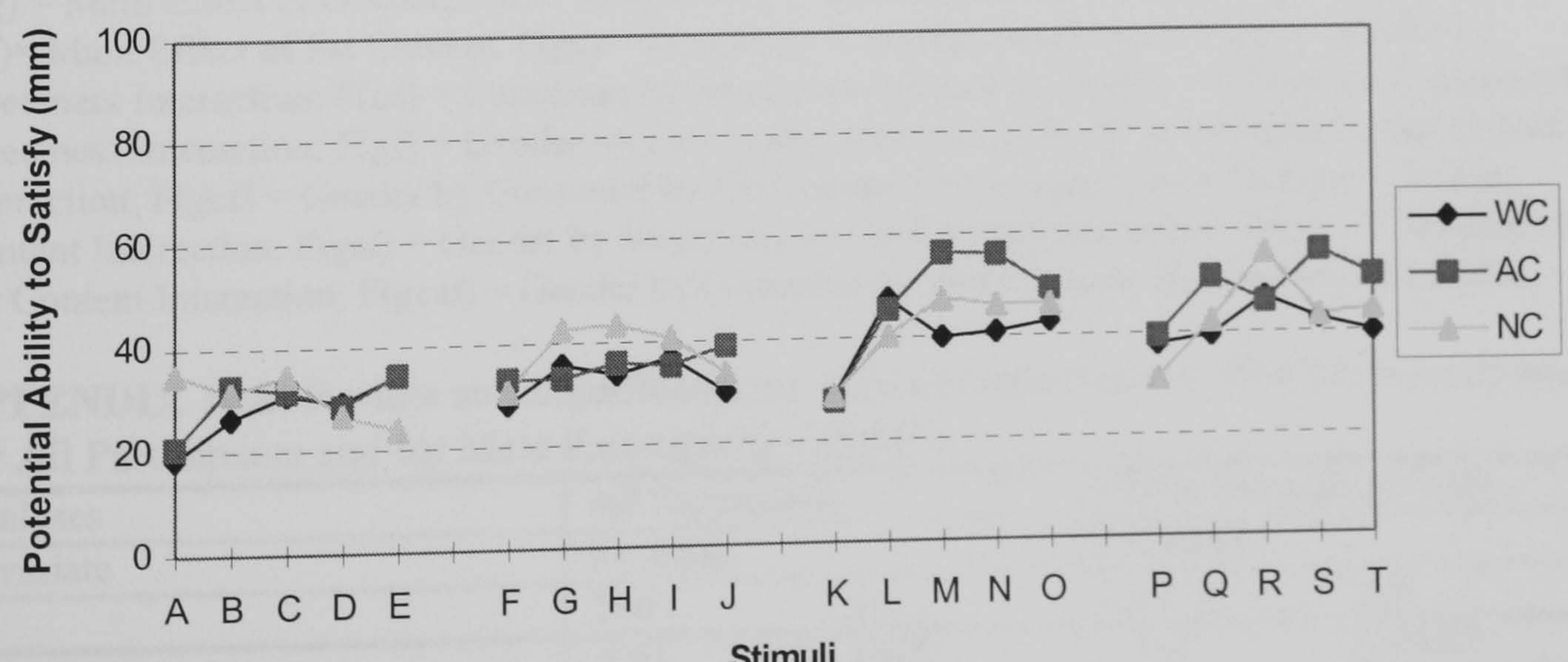
APPENDIX 10.4: Profile of Potential Ability to Satisfy for all Stimuli for All Participants Gender by Stimuli - Study 6



APPENDIX 10.5: Profile of Potential Ability to Fill all Stimuli for All Participants - Consumer by Stimuli - Study 6



APPENDIX 10.6: Profile of Potential Ability to Satisfy for all Stimuli for All Participants Consumer by Stimuli - Study 6



APPENDIX 10.7: Results and Significance of All Analyses on All Participants for All Scales of Subjective Measures of Appetite (mixed ANCOVA) - Study 6
Means and Standard Deviations are not provided.

Scale of PLEASANTNESS		
F(g)(1,41)=17.87, p<0.001 F(c)(2,41)=1.00, p=0.38 F(gc)(2,41)=1.59, p=0.22	**F(s)(4,168)=5.89, p<0.001** **F(gs)(4,168)=3.21, p=0.01** F(cs)(8,168)=0.96, p=0.47 F(gcs)(8,168)=0.71, p=0.69	**F(f)(3,126)=5.57, p=0.01** **F(gf)(3,126)=6.31, p=0.001** F(cf)(6,126)=1.23, p=0.30 F(gcf)(6,126)=1.04, p=0.40
	F(sf)(12,504)=2.44, p=0.004 F(gsf)(12,504)=1.65, p=0.08	F(csf)(24,504)=0.72, p=0.83 **F(gcsf)(24,504)=1.58, p=0.04**
Scale of SWEETNESS		
F(g)(1,41)=0.01, p=0.93 **F(c)(2,41)=3.66, p=0.03** F(gc)(2,41)=2.44, p=0.10	**F(s)(4,168)=369.03, p<0.001** F(gs)(4,168)=0.83, p=0.51 F(cs)(8,168)=1.13, p=0.34 F(gcs)(8,168)=0.45, p=0.89	**F(f)(3,126)=9.10, p<0.001** **F(gf)(3,126)=2.81, p=0.04** F(cf)(6,126)=1.64, p=0.14 F(gcf)(6,126)=0.61, p=0.72
	F(sf)(12,504)=3.66, p<0.001 F(gsf)(12,504)=0.87, p=0.58	F(csf)(24,504)=0.89, p=0.61 F(gcsf)(24,504)=0.92, p=0.58
Scale of FATTINESS		
F(g)(1,41)=11.64, p=0.001 F(c)(2,41)=0.02, p=0.98 F(gc)(2,41)=2.88, p=0.07	**F(s)(4,168)=2.86, p=0.02** F(gs)(4,168)=0.68, p=0.61 F(cs)(8,168)=0.60, p=0.78 F(gcs)(8,168)=1.66, p=0.11	**F(f)(3,126)=398.48, p<0.001** F(gf)(3,126)=2.37, p=0.07 F(cf)(6,126)=0.51, p=0.80 F(gcf)(6,126)=0.50, p=0.81
	F(sf)(12,504)=3.48, p<0.001 F(gsf)(12,504)=1.28, p=0.22	F(csf)(24,504)=0.95, p=0.54 F(gcsf)(24,504)=1.16, p=0.27
Scale of POTENTIAL ABILITY TO FILL		
F(g)(1,41)=5.08, p=0.03 F(c)(2,41)=0.34, p=0.71 F(gc)(2,41)=0.27, p=0.77	**F(s)(4,168)=13.22, p<0.001** F(gs)(4,168)=0.51, p=0.73 F(cs)(8,168)=0.83, p=0.58 F(gcs)(8,168)=1.83, p=0.08	**F(f)(3,126)=182.14, p<0.001** **F(gf)(3,126)=2.93, p=0.04** F(cf)(6,126)=0.29, p=0.94 F(gcf)(6,126)=0.43, p=0.86
	F(sf)(12,504)=2.06, p=0.02 F(gsf)(12,504)=1.03, p=0.42	F(csf)(24,504)=1.00, p=0.47 F(gcsf)(24,504)=1.17, p=0.27
Scale of POTENTIAL ABILITY TO SATISFY		
F(g)(1,41)=6.30, p=0.02 F(c)(2,41)=0.58, p=0.56 F(gc)(2,41)=1.38, p=0.26	**F(s)(4,168)=6.90, p<0.001** F(gs)(4,168)=2.00, p=0.10 F(cs)(8,168)=0.47, p=0.87 F(gcs)(8,168)=0.37, p=0.94	**F(f)(3,126)=19.04, p<0.001** **F(gf)(3,126)=8.17, p<0.001** F(cf)(6,126)=0.63, p=0.70 F(gcf)(6,126)=0.79, p=0.58
	F(sf)(12,504)=1.75, p=0.053 F(gsf)(12,504)=1.22, p=0.27	**F(csf)(24,504)=1.64, p=0.03** F(gcsf)(24,504)=1.20, p=0.24

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer; F(s) = Main Effect of Sweetness; F(f)= Main Effect of Fat Content. F(gc) = Gender by Consumer Interaction; F(gs) = Gender by Sweetness Interaction; F(cs) = Consumer by Sweetness Interaction; F(gcs) = Gender by Consumer by Sweetness Interaction; F(gf) = Gender by Fat Content Interaction; F(cf) = Consumer by Fat Content Interaction; F(gcf) = Gender by Consumer by Fat Content Interaction; F(sf) = Sweetness by Fat Content Interaction; F(gsf) = Gender by Sweetness by Fat Content Interaction; F(csf) = Consumer by Fat Content Interaction; F(gcsf) = Gender by Consumer by Sweetness by Fat Content Interaction.

APPENDIX 10.8: Results and Significance of All Covariate Tests in ANCOVA analyses, for All Participants and for Male Participants - Study 6

Analyses	All Participants		Male Participants Only	
Covariate	Restraint		Restraint	
	Test t	p	Test t	p
Pleasantness	**2.03**	**0.05**	2.07	0.052
Sweetness	-0.78	0.44	0.15	0.33
Fattiness	-1.38	0.17	**2.21**	**0.04**
Potential Ability to Fill	1.08	0.29	1.56	0.13
Potential Ability to Satisfy	**2.49**	**0.02**	2.47	**0.02**

APPENDIX 11.1: Full Questionnaire Set (Demographic Details, Drinks Food Frequency Questionnaire, Dutch Eating Behaviors Questionnaire (van Strien, Frijters, Bergers and Defares, 1986, Yale Eating Patterns Questionnaire (Kristeller and Rodin, 1989), Eating Disorder Inventory (Garner, Olmstead and Polivy, 1983) used in Study 7.

DIET AND EATING PATTERNS

The Nutrition Group at the University of Leeds is currently looking at the relationships between diet and various types of eating behaviours and eating patterns.

Enclosed are a number of questionnaires aimed to assess certain areas of your diet and all aspects of eating behaviour and from all different angles. Please complete all questionnaires. Please answer all questions, and do so as accurately and truthfully as possible. All answers will be kept completely confidential.

Having completed the questionnaires please return them to:
Katherine Appleton, Department of Psychology, University of Leeds, Leeds, LS2 9JT.

Thank-you for your time and co-operation.

Personal Details

Name:.. Phone (work / home) / Email:.......................................

Sex: Male / Female Date of Birth:.................................... Age:..............................

Height:................................. Weight:...................................... (please be as exact as possible)

Are you a smoker? Yes / No
If yes: How many cigarettes do you smoke per day?.......................

Are you a vegetarian? Yes / No Are you Currently Dieting? Yes / No

Diet Questionnaire
INSTRUCTIONS - Please consider each of the following foods, and mark down the quantity of each you consume, at present. Delete whether each is consumed on a daily or weekly rate.

Water - .... glasses per day / week

Regular squash - .... glasses per day / week

'Diet' squash - .... glasses per day / week

Regular carbonated drinks - .... cans per day / week

'Diet' carbonated drinks - .... cans per day / week

Coffee - .... cups per day / week, each with .... sugar
- .... cups per day / week, each with .... artificial sweetener

Tea - .... cups per day / week, each with .... sugar
- .... cups per day / week, each with .... artificial sweetener

Hot Chocolate - .... cups per day / week

Milk - .... glasses per day / week
Milkshake - .... glasses per day / week

Fruit Juice - .... glasses per day / week

Eating Patterns Questionnaires

INSTRUCTIONS - Please answer the following questions as carefully and honestly as possible. Read each question and simply fill in the column which best applies to you

	Never	Seldom	Sometimes	Often	Very Often
1. If you have put on weight, do you eat less than you usually do?	O	O	O	O	O
2. Do you have a desire to eat when you are irritated?	O	O	O	O	O
3. If food tastes good to you, do you eat more than you usually do?	O	O	O	O	O
4. Do you try and eat less at meal times than you would like to eat?	O	O	O	O	O
5. Do you have a desire to eat when you have nothing to do?	O	O	O	O	O
6. Do you have a desire to eat when you are fed up?	O	O	O	O	O
7. If food smells and looks good, do you eat more than you usually do?	O	O	O	O	O
8. How often do you refuse food or drink offered because you are worried about how you weigh?	O	O	O	O	O
9. Do you have a desire to eat when you are feeling lonely?	O	O	O	O	O
10. If you see or smell something delicious, do you have a desire to eat it?	O	O	O	O	O
11. Do you watch exactly what you eat?	O	O	O	O	O
12. Do you have a desire to eat when somebody disappoints you?	O	O	O	O	O
13. If you have something delicious to eat, do you eat it straight away?	O	O	O	O	O
14. Do you deliberately eat foods that are slimming?	O	O	O	O	O
15. Do you have a desire to eat when you are cross?	O	O	O	O	O
16. Do you have a desire to eat when you are expecting something to happen?	O	O	O	O	O
17. If you walk past the baker do you have a desire to buy something delicious?	O	O	O	O	O
18. When you have eaten too much, do you eat less than usual on the following days?	O	O	O	O	O
19. Do you get a desire to eat when you are anxious, worried or tense?	O	O	O	O	O
20. If you walk past a snack bar or cafe, do you have a desire to buy something delicious?	O	O	O	O	O
21. Do you deliberately eat less in order not to become heavier?	O	O	O	O	O
22. Do you have a desire to eat when things are going against you or when things have gone wrong?	O	O	O	O	O
23. If you see others eating, do you also have a desire to eat?	O	O	O	O	O
24. How often do you try not to eat between meals because you are watching your weight?	O	O	O	O	O
25. Do you have a desire to eat when you are frightened?	O	O	O	O	O
26. Can you resist eating delicious foods?	O	O	O	O	O
27. How often in the evening do you try not to eat because you are watching your weight?	O	O	O	O	O
28. Do you have a desire to eat when you are disappointed?	O	O	O	O	O
29. Do you eat more than usual when you see others eating?	O	O	O	O	O
30. Do you think about how much you weigh before deciding how much to eat?	O	O	O	O	O
31. Do you have a desire to eat when you are upset?	O	O	O	O	O
32. When you see someone preparing a meal, does it make you want to eat something?	O	O	O	O	O
33. Do you have a desire to eat when you are bored or restless?	O	O	O	O	O

---

1. I have late night snacks	O	O	O	O	O
2. I snack or nibble when watching TV	O	O	O	O	O
3. I snack and nibble when preparing meals	O	O	O	O	O
4. I have never attempted to follow a regular dietary program	O	O	O	O	O
5. Eating keeps me feeling better emotionally	O	O	O	O	O
6. I open the refrigerator door and look even if I do not take out any food	O	O	O	O	O
7. I eat more on holidays and vacations than usual	O	O	O	O	O
8. I have dieted successfully in the past but I seem to gain back the weight I loose	O	O	O	O	O
9. I consciously restrain my eating	O	O	O	O	O
10. I have an uncontrollable urge to eat even to the point of making myself sick	O	O	O	O	O

	Never	Seldom	Sometimes	Often	Very Often
11. I can picture what I will look like when I am thinner than I am now	O	O	O	O	O
12. I'm willing to take a special trip to the shop or bake something to satisfy my cravings	O	O	O	O	O
13. I eat more on weekends than on weekdays	O	O	O	O	O
14. I eat food even when it doesn't taste very good	O	O	O	O	O
15. I am familiar with the caloric value of most foods	O	O	O	O	O
16. When small meals are put in front of me, I am satisfied without second helpings	O	O	O	O	O
17. Watching other people eat makes me hungry	O	O	O	O	O
18. I think about and look forward to each meal	O	O	O	O	O
19. I often eat most when I have already eaten a lot	O	O	O	O	O
20. When the afternoon comes, my stomach growls	O	O	O	O	O
21. I crave sweets more than other foods	O	O	O	O	O
22. I am more likely to overeat at dinner	O	O	O	O	O
23. When I don't eat (or if dieting) I become nervous and anxious	O	O	O	O	O
24. I am more likely to overeat between lunch and dinner	O	O	O	O	O
25. I eat when I'm not really hungry, just because food is available	O	O	O	O	O
26. I feel dizzy and faint when I go without food	O	O	O	O	O
27. I am more likely to overeat after dinner	O	O	O	O	O
28. I just seem to crave food	O	O	O	O	O
29. I buy refreshments at movies, etc.,	O	O	O	O	O
30. When I am bored I eat for something to do	O	O	O	O	O
31. I finish whatever is put in front of me	O	O	O	O	O
32. Snacking is a big problem for me	O	O	O	O	O
33. I think about food when I am not actually eating or preparing it	O	O	O	O	O
34. I'm likely to eat too much if I'm doing something else at the same time (watching TV, reading)	O	O	O	O	O
35. I like to celebrate important events by going out to eat	O	O	O	O	O
36. I eat more when I am alone	O	O	O	O	O
37. I find eating is the most pleasurable activity of the day	O	O	O	O	O
38. I overeat when I am angry or depressed	O	O	O	O	O

For the next part of the questionnaire please indicate how important the following statements are in indicating to you to stop eating.

	Very Important	Quite Important	Not Very Imp't	Not At All Imp't
In the afternoon,				
39. My stomach is comfortably full	O	O	O	O
40. I have a satiated feeling	O	O	O	O
At dinner,				
41. My stomach is stuffed	O	O	O	O
42. There is no more food in the serving bowls	O	O	O	O
43. I've eaten enough calories	O	O	O	O
44. One more bite would make me feel nauseous	O	O	O	O
45. I feel guilty	O	O	O	O
46. There is no more food at all	O	O	O	O
47. There is no more food on the plate	O	O	O	O
48. I feel nauseous	O	O	O	O
49. If I eat more, I'll feel bad physically (gas, indigestion, etc.)	O	O	O	O
In the evening,				
50. My stomach is stuffed	O	O	O	O
51. I feel guilty	O	O	O	O
52. My stomach is comfortably full	O	O	O	O

ices

	Very Important	Quite Important	Not Very Imp't	Not At All Imp't
53. People will think I'm a pig if I eat more	O	O	O	O
55. There is no more food	O	O	O	O
56. I'll feel bloated in the morning	O	O	O	O
57. I feel nauseous	O	O	O	O
58. If I eat more I'll feel bed physically (gas, indigestion, etc.)	O	O	O	O

For the next part of the questionnaire please indicate how important you consider the following factors to be in weight problems?

59. Hereditary factors	O	O	O	O
60. Physiological Factors (metabolism, thyroid, etc.)	O	O	O	O
61. Lack of knowledge about which foods I should and shouldn't eat	O	O	O	O
62. Lack of knowledge about specific techniques in controlling my eating	O	O	O	O
63. Lack of encouragement from family / friends	O	O	O	O
64. Insufficient time to shop / prepare foods correctly	O	O	O	O
65. Large Body frame	O	O	O	O
66. Too little exercise	O	O	O	O
67. Poor eating habits	O	O	O	O
68. Lack of motivation	O	O	O	O
69. Anxiety or stress	O	O	O	O
70. Depression	O	O	O	O

Please answer the following questions as carefully and honestly as possible. Read each question and simply fill in the column which best applies to you

	Always	Usually	Often	Sometimes	Rarely	Never
1. I eat sweets and carbohydrates without feeling nervous	O	O	O	O	O	O
2. I think that my stomach is too big	O	O	O	O	O	O
3. I wish that I could return to the security of my childhood	O	O	O	O	O	O
4. I eat when I am upset	O	O	O	O	O	O
5. I stuff myself with food	O	O	O	O	O	O
6. I wish that I could be younger	O	O	O	O	O	O
7. I think about dieting	O	O	O	O	O	O
8. I get frightened when my feelings are too strong	O	O	O	O	O	O
9. I think that my thighs are too large	O	O	O	O	O	O
10. I feel ineffective as a person	O	O	O	O	O	O
11. I feel extremely guilty after overeating	O	O	O	O	O	O
12. I think that my stomach is just the right size	O	O	O	O	O	O
13. Only outstanding performance is good enough in my family	O	O	O	O	O	O
14. The happiest time in life is when you are a child	O	O	O	O	O	O
15. I am open about my feelings	O	O	O	O	O	O
16. I am terrified of gaining weight	O	O	O	O	O	O
17. I trust others	O	O	O	O	O	O
18. I feel alone in the world	O	O	O	O	O	O
19. I feel satisfied with the shape of my body	O	O	O	O	O	O
20. I feel generally in control of things in my life	O	O	O	O	O	O
21. I get confused about what emotion I am feeling	O	O	O	O	O	O
22. I would rather be an adult than a child	O	O	O	O	O	O
23. I can communicate with others easily	O	O	O	O	O	O
24. I wish I were someone else	O	O	O	O	O	O
25. I exaggerate or magnify the importance of my weight	O	O	O	O	O	O
26. I can clearly identify what emotion I am feeling	O	O	O	O	O	O
27. I feel inadequate	O	O	O	O	O	O
28. I have gone on eating binges where I have felt that I could not stop.	O	O	O	O	O	O

	Always	Usually	Often	Sometimes	Rarely	Never
29. As a child, I tried very hard to avoid disappointing my parents and teachers	O	O	O	O	O	O
30. I have close relationships	O	O	O	O	O	O
31. I like the shape of my buttocks	O	O	O	O	O	O
32. I am preoccupied with the desire to be thinner	O	O	O	O	O	O
33. I don't know what's going on inside me	O	O	O	O	O	O
34. I have trouble expressing my emotions to others	O	O	O	O	O	O
35. The demands of adulthood are too great	O	O	O	O	O	O
36. I hate being less than best at things	O	O	O	O	O	O
37. I feel secure about myself	O	O	O	O	O	O
38. I think about bingeing (overeating)	O	O	O	O	O	O
39. I feel happy that I am not a child anymore	O	O	O	O	O	O
40. I get confused as to whether or not I am hungry	O	O	O	O	O	O
41. I have a low opinion of myself	O	O	O	O	O	O
42. I feel that I can achieve my standards	O	O	O	O	O	O
43. My parents have expected excellence of me	O	O	O	O	O	O
44. I worry that my feelings will get out of control	O	O	O	O	O	O
45. I think that my hips are too big	O	O	O	O	O	O
46. I eat moderately in front of others and stuff myself when they're gone	O	O	O	O	O	O
47. I feel bloated after eating a normal meal	O	O	O	O	O	O
48. I feel that people are happiest when they are children	O	O	O	O	O	O
49. If I gain a pound I worry that I will keep gaining	O	O	O	O	O	O
50. I feel that I am a worthwhile person	O	O	O	O	O	O
51. When I am upset, I don't know if I am sad, frightened or angry	O	O	O	O	O	O
52. I feel that I must do things perfectly, or not do them at all	O	O	O	O	O	O
53. I have the thought of trying to vomit in order to lose weight	O	O	O	O	O	O
54. I need to keep people at a certain distance (feel uncomfortable if someone tries to get too close)	O	O	O	O	O	O
55. I think that my thighs are just the right size	O	O	O	O	O	O
56. I feel empty inside (emotionally)	O	O	O	O	O	O
57. I can talk about personal thoughts or feelings	O	O	O	O	O	O
58. The best years of your life are when you become an adult	O	O	O	O	O	O
59. I think that my buttocks are too large	O	O	O	O	O	O
60. I have feelings that I can't quite identify	O	O	O	O	O	O
61. I eat or drink in secrecy	O	O	O	O	O	O
62. I think that my hips are just the right size	O	O	O	O	O	O
63. I have extremely high goals	O	O	O	O	O	O
64. When I am upset, I worry that I will start eating	O	O	O	O	O	O

Are there any comments you would like to make?

Thank you for completing all questionnaires.

Please now return them either to the boxes provided in the Roger Stevens Building or the Union Building at the University or return them by post to Katherine Appleton, Department of Psychology, Leeds University, Leeds, LS2 9JT.

APPENDIX 11.2: Scores on All Eating Attitudes and Behaviour Scales (means (st.dev.)). for all Respondents - Study 7

		Consumers			
Scale	Sex	WC	AC	NC	Significance - MANOVA
D.E.B.Q.-	M	19.0 (8.7)	31.9 (7.4)	15.5 (6.4)	F(g)(13,80)=0.69, p=0.76
Restrained	F	22.3 (8.0)	29.7 (10.0)	18.9 (6.0)	**F(c)(26,162)=2.34, p=0.001**
Eating					F(gc)(26,162)=1.13, p=0.76
D.E.B.Q.-	M	27.7 (9.6)	28.4 (11.4)	28.0 (8.7)	
Emotional	F	30.9 (11.0)	35.1 (12.3)	29.9 (9.7)	Significance
Eating					Consumer - Univariate F
D.E.B.Q.-	M	30.0 (5.7)	29.2 (6.5)	32.3 (4.6)	D.E.B.Q.- Restrained Eating
External	F	31.1 (4.6)	32.6 (5.6)	32.5 (4.0)	**F(2,92)=14.55, p<0.001**
Eating					D.E.B.Q.- Emotional Eating
Y.E.P.Q.-	M	15.4 (8.3)	20.0 (10.5)	20.7 (12.0)	F(2,92)=0.19, p=0.83
Uninhibited	F	14.0 (22.2)	16.3 (10.2)	23.6 (11.5)	D.E.B.Q.- External Eating
Eating					F(2,92)=0.72, p=0.49
Y.E.P.Q.-	M	1.7 (12.5)	-5.9 (11.2)	2.8 (10.2)	Y.E.P.Q.- Uninhibited Eating
Uninterested	F	-7.0 (22.3)	-8.1 (11.5)	-1.1 (7.7)	F(2,92)=1.64, p=0.20
Eating					Y.E.P.Q.- Uninterested Eat'g
Y.E.P.Q.-	M	21.0 (11.8)	31.8 (14.1)	21.2 (11.9)	F(2,92)=2.58, p=0.08
Bingeing	F	29.7 (23.1)	32.5 (12.5)	23.8 (6.2)	Y.E.P.Q.- Bingeing
					F(2,92)=3.91, p=0.02
Y.E.P.Q.-	M	-35.4 (10.9)	-33.8 (14.7)	-35.4 (18.1)	Y.E.P.Q.- Guilty Dieting
Guilty	F	-29.8 (25.7)	-30.4 (11.9)	-35.3 (12.2)	F(2,92)=0.31, p=0.74
Dieting					Y.E.P.Q.- High S-M'd Eat'g
Y.E.P.Q.-	M	7.2 (6.6)	-0.2 (7.7)	3.3 (10.4)	F(2,92)=1.26, p=0.29
High Self-M'd	F	2.4 (7.2)	1.0 (7.8)	0.9 (10.4)	Y.E.P.Q.- Low S-M'd Eat'g
Eating					F(2,92)=2.47, p=0.09
Y.E.P.Q.-	M	-14.2 (11.8)	-4.9 (7.9)	-14.4 (12.6)	E.D.I.- Body Dissatisfact'n
Low Self-M'd	F	-7.8 (8.5)	-4.3 (10.0)	-6.4 (9.3)	**F(2,92)=10.60, p<0.001**
Eating					E.D.I.- Weight Preoccupat'n
E.D.I.-	M	3.1 (4.6)	14.4 (10.0)	4.3 (4.0)	**F(2,92)=11.20, p<0.001**
Body	F	7.8 (7.0)	14.6 (9.2)	4.6 (5.7)	E.D.I.- A.N. Restrictor Type
Dissatisfaction					**F(2,92)=6.58, p<0.001**
E.D.I.-	M	4.3 (5.4)	21.4 (14.8)	5.6 (6.4)	E.D.I.- A.N. Bulimia Type
Weight	F	10.2 (11.5)	23.3 (16.5)	5.6 (6.7)	**F(2,92)=5.27, p<0.001**
Preoccupation					
E.D.I.-	M	11.9 (9.7)	37.7 (14.5)	19.2 (17.9)	
A.N. Restrictor	F	24.0 (17.7)	36.5 (20.9)	21.7 (15.0)	
Type					
E.D.I.-	M	12.1 (9.9)	38.7 (14.7)	21.5 (22.8)	
A.N. Bulimia	F	25.8 (21.2)	40.9 (25.2)	22.8 (15.2)	
Type					

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer.
F(gc) = Gender by Consumer Interaction.

APPENDIX 11.3: Levels of B.M.I. (means (st.dev.)), for all Respondents - Study 7

		Consumers			
Scale	Sex	WC	AC	NC	Significance - ANOVA
B.M.I.	M	22.6 (2.0)	26.0 (3.0)	22.5 (2.7)	F(g)(1,116)=0.11, p=0.75
	F	22.3 (2.1)	25.6 (4.9)	22.4 (2.9)	**F(c)(2,116)=12.39, p<0.001**
					F(gc)(2,116)=0.02, p=0.98

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer.
F(gc) = Gender by Consumer Interaction.

APPENDIX 12.1: An example of a Complete Food Diary, used in Study 8.

Page 1

NAME

STUDY DAY

DAY

DATE

return to: Katherine Appleton,
BioPsychology Group, Department of Psychology, University of Leeds. CODE

Page 2

Meal ________ /Snack With *partner* Where *home*
Premeal Time *9:00* Postmeal Time: *9:30* Premeal Physical Activity 1 2 3 4 5 6 7 8 9

Brand Name	Food Item/s (inc. desc'n and prep'n)	Amount
Buffalo Creek	*Medium Sparkling White Wine*	*1 medium wine-glass*

Started because - boredom, break, content, empty stomach, exposure, habit, hunger, influenced, location, medicinal, mouthfeel, negative emotion, opportunity, positive emotion, preparation, provided, reward, social situation, taste, time, thirst, tired/weak, with others consuming, other ....
Stopped because all I allow myself, everyone else had finished, food item finished, food item spoilt, full, habit, nauseous, potentially satisfied, reduced emotional state, reduced/satisfied/oversatisfied bodily needs, reduced/satisfied/oversatisfied sensational needs, situation, social, time, other ....

Page 3

INSTRUCTIONS

- Please find on the following pages a dietary diary. This is for one day and is split up into sections for each eating bout. An eating bout refers to each separate occasion on which you eat and/or drink anything.

- For each eating bout please record absolutely everything you eat and drink, and include: amount of each item consumed - use weight if possible otherwise use household measures e.g. 1 teaspoon of sugar, 1 ladle of soup;
the brand name of each item if known/applicable;
any information on description or preparation of the item that may be applicable - e.g. semi-skimmed milk, boiled potatoes.
Please include as much detail as you can, whatever you eat or drink.

Page 4

- For each eating bout please also record:
whether it is a meal or a snack - if it was a meal please detail which one, if it was anything else call it a snack;
who you were eating/drinking with - e.g. no-one, friends, colleagues, partner;
where you were eating/drinking - e.g. home, work, restaurant, on the move;
the time at which you started eating and stopped eating;
the amount of physical activity participated in prior to eating/drinking (see later);
the reasons why you started eating and why you stopped eating (see later)

- Please complete the diary as you eat/drink, rather than from memory at the end of the day.

- Please make sure you include all drinks including water

- Please make sure you include all snacks

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- Please include as much detail as possible for composite meals and include the proportion of the mixture actually consumed

- Please include any dietary supplements or sweet-based medicines e.g. lockets

- Please do not alter what you eat because you are recording it - foods that may be unusual please simply describe in detail, liken to well-known foods or bring in packaging if possible; foods that are hard to describe please liken to well-known foods and bring in packaging if possible, foods that may seem tiny in quantity or nutrition e.g. 1 lollipop may add up over the day. Finally whether you have a healthy diet or not is of no consequence and no interest to us - please write down **everything you eat and drink** and please be as truthful as possible.

- Please also collect the packets/wrappers of anything you eat/drink if possible and return them with your diary.

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An example of a completed food diary for one eating/drinking bout is provided on the inside of the front cover. A list of popular foods and drinks will also be provided for you to show you the types of information needed. If the foods/drinks you have consumed are not on this list please refer to similar items.

If you have any questions or any questions please contact:
Katherine Appleton - 2335741 (or 2335754)
Psychology Department, University of Leeds, LS2 9JT.

Pre-meal Physical Activity refers to average activity levels since you last consumed anything. Activity is measured on a 9 point scale as below. Please simply circle the number referring to the relevant level of activity. Scale Items: 1=none, e.g. sleeping, 2=very light, e.g. sitting, eating, writing, 3=light, e.g. washing, dressing, 4=light/moderate, e.g. moderate walking, 5=moderate e.g. light manual work - barwork, decorating, 6=moderate/heavy e.g. brisk walking, 7=heavy e.g. light aerobics, slow jogging, 8=intense e.g. football, aerobics, 9=very intense e.g. running, mountain climbing.

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Reasons for starting eating are measured using the following choices:
boredom, break (from whatever you're doing), content (fluid, energy, alcohol, caffeine, etc.), empty stomach, exposure (e.g. sight, smell), habit (e.g. always eat breakfast before I go to work, always have a coffee with a cigarette), hunger, influenced (by alcohol or other drugs), location (e.g. in a pub), medicinal, mouthfeel, negative emotion (e.g. anxiety, depression, anger, tension), opportunity (e.g. had to eat 2 hours before going to gym), positive emotion (e.g. arousal, excitement), preparation (e.g. had to drink to sustain fluid levels whilst at the gym), provided (for you), reward, social situation (e.g. polite to have a cup of tea when visiting, tradition to have a drink when meeting at a pub), taste, time (of day), thirst, tired/weak, with others consuming
An 'other' choice will also be available if none of the above are applicable.
Please simply circle the one or ones that are relevant to that particular eating bout. Please circle as many as are appropriate, and please don't worry if you seem to be circling the same ones all the time - different people eat for different reasons and at different times.

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Reasons for stopping eating are measured using the following choices:
all I allow myself, everyone else had finished, food item finished, food item spoilt (e.g. coffee had gone cold, spilt wine over food), full, habit (e.g. always eat the same for breakfast), nauseous, potential needs satisfied (e.g. had eaten all I would need for an hour at the gym), reduced emotional state, reduced/satisfied/oversatisfied bodily needs, reduced/satisfied/oversatisfied sensational needs, situation constraints (e.g. friends changing pub, pub closing), social constraints (e.g. it would be rude to ask for a second helping), time constraints, reduced/satisfied/oversatisfied - refer in turn to e.g. less hungry than before, not hungry any more, bloated.
Please simply circle the one or ones that are relevant to that particular eating bout. Please circle as many as are appropriate, and please don't worry if you seem to be circling the same ones all the time - different people eat for different reasons and at different times.

Meal ____________________/Snack With ________________ Where ______________________

Premeal Time ________Postmeal Time: ____________ Premeal Physical Activity 1 2 3 4 5 6 7 8 9

Brand Name	Food Item/s (inc. desc'n and prep'n)	Amount

Started because - boredom, break, content, empty stomach, exposure, habit, hunger, influenced, location, medicinal, mouthfeel, negative emotion, opportunity, positive emotion, preparation, provided, reward, social situation, taste, time, thirst, tired/weak, with others consuming, other ....

Stopped because - all I allow myself, everyone else had finished, food item finished, food item spoilt, full, habit, nauseous, potentially satisfied, reduced emotional state, reduced/satisfied/oversatisfied bodily needs, reduced/satisfied/oversatisfied sensational needs, situation, social, time, other ....

Eating Episode Page 2

Brand Name	Food Item/s (inc. desc'n and prep'n)	Amount

please turn back and complete why you stopped eating

APPENDIX 12.2: Food Frequency Questionnaire (Margetts, Cade and Osmond, 1989), used in Study 8.

LEEDS FOOD AND NUTRITION SURVEY

Please read the following instructions carefully before completing the questionnaire

1. Please answer ALL the questions

2. Select the answer that best applies to your situation and TICK the appropriate column. Only tick ONE box on **each** line (i.e. per food). If you make a mistake cross through the incorrect tick and tick the correct answer.

HOW OFTEN DO YOU EAT EACH OF THE FOLLOWING FOODS ? (tick the appropriate box)
Please record what you normally eat and drink.

How often do you eat the following foods ?	2 or more times a day	Every day	3-5 times a week	1-2 times a week	1-3 times a month	Rarely / never
DAIRY PRODUCTS						
Milk (including in tea/coffee) : Whole	☐	☐	☐	☐	☐	☐
: Semi-Skimmed	☐	☐	☐	☐	☐	☐
: Skimmed	☐	☐	☐	☐	☐	☐
Butter	☐	☐	☐	☐	☐	☐
Margarine (e.g. Stork, Clover)	☐	☐	☐	☐	☐	☐
Polyunsaturated Margarine (e.g. Flora)	☐	☐	☐	☐	☐	☐
Low Fat Spreads (e.g. Outline, Gold)	☐	☐	☐	☐	☐	☐
Ice Cream	☐	☐	☐	☐	☐	☐
Yoghurt, Fromage Frais	☐	☐	☐	☐	☐	☐
Cheese (e.g. cheddar, stilton, cream cheese)	☐	☐	☐	☐	☐	☐
Low Fat Cheese (e.g. cottage, reduced fat)	☐	☐	☐	☐	☐	☐
Eggs - Fried	☐	☐	☐	☐	☐	☐
- not Fried (boiled, poached, in baking)	☐	☐	☐	☐	☐	☐
Cheese and/ or Egg Dishes (e.g. pizza, quiche, macaroni cheese)	☐	☐	☐	☐	☐	☐
MEATS AND FISH						
Beef - roast/steak	☐	☐	☐	☐	☐	☐
Lamb - roast/chops	☐	☐	☐	☐	☐	☐
Pork - roast/chops	☐	☐	☐	☐	☐	☐
Chicken, Turkey or other poultry	☐	☐	☐	☐	☐	☐
Bacon or Gammon	☐	☐	☐	☐	☐	☐
Meat Dishes (e.g. stew, curry, chilli, lasagne)	☐	☐	☐	☐	☐	☐
Canned Meats (e.g. corned beef, ham)	☐	☐	☐	☐	☐	☐
Meat pies, Sausage rolls or Pasties	☐	☐	☐	☐	☐	☐
Sausages or Beefburgers	☐	☐	☐	☐	☐	☐
Liver, Kidney, Pate (other offal products)	☐	☐	☐	☐	☐	☐
Fish and Seafood - not fried	☐	☐	☐	☐	☐	☐
- fried	☐	☐	☐	☐	☐	☐
- canned (e.g. tuna, salmon)	☐	☐	☐	☐	☐	☐
BREAD AND CEREALS						
White Bread	☐	☐	☐	☐	☐	☐
Brown / Granary Bread	☐	☐	☐	☐	☐	☐
Wholemeal Bread (including chapattis)	☐	☐	☐	☐	☐	☐
Sweet Biscuits (plain and chocolate)	☐	☐	☐	☐	☐	☐
Crackers / Crispbread	☐	☐	☐	☐	☐	☐
Cakes, Buns, Pastries	☐	☐	☐	☐	☐	☐
Puddings (e.g. fruit pies, cheesecake)	☐	☐	☐	☐	☐	☐
Breakfast Cereal:						
- High Fibre (e.g. bran flakes, Weetabix)	☐	☐	☐	☐	☐	☐
- Ordinary (e.g. cornflakes, rice krispies)	☐	☐	☐	☐	☐	☐
- Muesli	☐	☐	☐	☐	☐	☐
Rice or Pasta	☐	☐	☐	☐	☐	☐

How often do you eat the following foods ?	2 or more times a day	Every day	3-5 times a week	1-2 times a week	1-3 times a month	Rarely /never
FRUIT AND VEGETABLES						
Apples, Pears	☐	☐	☐	☐	☐	☐
Oranges, Grapefruit or other citrus fruit	☐	☐	☐	☐	☐	☐
Bananas	☐	☐	☐	☐	☐	☐
Green Vegetables (e.g. cabbage, peas, broccoli)	☐	☐	☐	☐	☐	☐
Carrots, Tomatoes (fresh or canned)	☐	☐	☐	☐	☐	☐
Other vegetables (including salad vegetables)	☐	☐	☐	☐	☐	☐
Baked Beans	☐	☐	☐	☐	☐	☐
Other Beans / Lentils (e.g. dahl)	☐	☐	☐	☐	☐	☐
Vegetable dishes (e.g. stew, curry - NO meat)	☐	☐	☐	☐	☐	☐
Potatoes - chips, roasted, fried	☐	☐	☐	☐	☐	☐
- not fried (boiled, baked)	☐	☐	☐	☐	☐	☐
BEVERAGES						
Beer or Lager	☐	☐	☐	☐	☐	☐
Wine, Sherry or Spirits	☐	☐	☐	☐	☐	☐
Tea or Coffee	☐	☐	☐	☐	☐	☐
Squash or Fizzy Drinks	☐	☐	☐	☐	☐	☐
Low Calorie Drinks	☐	☐	☐	☐	☐	☐
Pure Fruit Juices	☐	☐	☐	☐	☐	☐
MISCELLANEOUS						
Chocolate	☐	☐	☐	☐	☐	☐
Sweets	☐	☐	☐	☐	☐	☐
Sweet spreads (e.g. jam, marmalade)	☐	☐	☐	☐	☐	☐
Sugar (e.g. in tea/coffee, on cereal)	☐	☐	☐	☐	☐	☐
Crisps and savoury snacks	☐	☐	☐	☐	☐	☐
Nuts (including peanut butter)	☐	☐	☐	☐	☐	☐
Sauces and Pickles (e.g. Ketchup, Branston)	☐	☐	☐	☐	☐	☐
Salad oils, Dressings, Mayonnaise	☐	☐	☐	☐	☐	☐

Are there any other foods that have not been recorded that you regularly eat ?

Please write what they are and how often you eat them:

______________	☐	☐	☐	☐	☐	☐
______________	☐	☐	☐	☐	☐	☐

PLEASE NOW COMPLETE THE FOLLOWING QUESTIONS ABOUT YOURSELF:

1. In what year were you born ? ______________

2. Are you MALE ☐ or FEMALE ☐ (please tick)

3. How tall are you? _____ feet _____inches **OR** _____ metres

4. How much do you weigh? _____ stones _____ lbs **OR** _____ Kgs

5. How would you rate your general health ? (please circle one number on the scale of 1-6)

not at all healthy 1 2 3 4 5 6 *extremely healthy*

If you have any additional comments to make, we would be grateful to receive them.
THANK YOU FOR YOUR TIME AND CO-OPERATION

APPENDIX 12.3: 24hr. Recall Sheet, used in Study 8.

24hr. Recall.

Please recall absolutely everything you ate and drank yesterday, from the time you got up to the time you went to bed. Include **absolutely everything -** all drinks, all snacks, all cooking oil, seasonings and condiments, all dietary supplements, all medicines and all chewing gum.

Please also include for each eating episode: the time of starting and stopping eating / drinking, where you eating and who you were with (the number of people and their relation to you (e.g. friends, family, partner), the brand names and details of all foods / drinks consumed, and the quantity consumed.

Once you have finished please go back through your day and check for any missing drinks or snacks, and anything you may have consumed whilst doing other things, particularly whilst preparing food

Meal Time	With Where	Brand Name	Food Item/s (inc. desc'n and prep'n)	Amount

APPENDIX 12.4: Energy Expenditure Equations, used in Study 8

Estimated Energy Expenditure = Basal Metabolic Rate x Physical Activity Ratio
(kcal./day) (kcal./day) (kcal./day)

For Males (18-29yrs.) Basal Metabolic Rate = 15.1 x Body Weight (kg.) + 692
(30-59yrs.) Basal Metabolic Rate = 11.5 x Body Weight (kg.) + 873
For Females (18-29yrs.) Basal Metabolic Rate = 14.8 x Body Weight (kg.) + 487
(30-59yrs.) Basal Metabolic Rate = 8.3 x Body Weight (kg.) + 846

Physical Activity Ratio = 0.7 x Physical Activity Level

Body Weight (kg.) was measured for each participant prior to the start of the study. Physical Activity Level was self-reported by each participant throughout the study, using a nine-point scale (Bouchard, Tremblay, Leblanc, Lortie, Savard and Theriault, 1983) Equations for Estimated Energy Expenditure and Basal Metabolic Rate are taken from the Department of Health, Report on Health and Social Sciences - 41, Dietary Reference Values for Food Energy and Nutrients for the United Kingdom (1996).

APPENDIX 12.5: Quantity Consumed (per day) - Means, (Standard Deviations), and the Results of All Analyses for All Participants - Study 8

		Consumer			
Measure	Sex	WC	AC	NC	Significance
Weight of Food (gram.)	M	1354 (204)	1311 (283)	1250 (171)	F(g)(1,47)=0.07, p=0.79
	F	1195 (181)	1434 (443)	1185 (441)	F(c)(2,47)=2.20, p=0.13
					F(gc)(2,47)=0.85, p=0.44
Total Weight (gram.)	M	4119 (779)	3581 (1124)	3327 (838)	F(g)(1,47)=0.26, p=0.61
	F	3041 (740)	4362 (1901)	3057 (1056)	F(c)(2,47)=1.68, p=0.20
					F(gc)(2,47)=1.49, p=0.07
Energy (kcal.)	M	2809 (530)	2108 (634)	2617 (493)	F(g)(1,47)= 2.59, p=0.12
	F	2184 (438)	1922 (564)	2340 (634)	F(c)(2,47)= 1.28, p=0.29
					F(gc)(2,47)=0.26, p=0.78
Energy - CHO (%kcal.)	M	42.9 (6.3)	48.8 (4.6)	47.9 (7.3)	F(g)(1,47)=0.01, p=0.97
	F	46.6 (9.1)	48.9 (13.3)	48.4 (5.9)	F(c)(2,47)=0.84, p=0.44
					F(gc)(2,47)=0.07, p=0.93
Energy - Fat (%kcal.)	M	34.8 (5.2)	30.6 (8.3)	30.0 (6.4)	F(g)(1,47)=0.07, p=0.79
	F	33.0 (8.0)	28.6 (10.8)	31.5 (5.1)	F(c)(2,47)=0.25, p=0.78
					F(gc)(2,47)=0.73, p=0.49
Energy - Protein (%kcal.)	M	14.0 (1.4)	17.0 (4.3)	14.4 (2.1)	F(g)(1,47)=2.99, p=0.09
	F	14.8 (2.0)	16.0 (2.8)	12.1 (1.7)	**F(c)(2,47)=4.95, p=0.01**
					F(gc)(2,47)=0.99, p=0.38
Sweet Foods (%freq.)	M	37.2 (18.7)	68.3 (18.6)	64.3 (11.2)	F(g)(1,47)=1.74, p=0.20
	F	34.8 (17.8)	75.3 (14.4)	77.1 (7.1)	F(c)(2,47)=28.65, p<0.001
					F(gc)(2,47)=0.99, p=0.38

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer.
F(gc) = Gender by Consumer Interaction.

APPENDIX 12.6: Results and Significance of All Covariate Tests in ANCOVA Analyses, for all participants, for male participants only and for female participants only - Study 8

		All Participants		Males Only		Females Only	
Analysis	Covariate	Test t	p	Test t	p	Test	p
Weight of Food Consumed (gram.)	Restraint	1.41	0.24	1.64	0.22	0.10	0.76
	Classification	0.01	0.95	2.08	0.17	**9.17**	**0.01**
	Meal Type	1.64	0.21	0.12	0.74	2.41	0.14
	Relation	0.27	0.61	1.15	0.30	0.30	0.60
	Number	0.47	0.50	0.01	0.93	1.57	0.25
	Location	1.50	0.23	0.06	0.81	0.96	0.63
	Time	0.00	0.99	1.23	0.29	0.86	0.23
	Duration	1.70	0.20	2.62	0.13	0.01	0.96
Total Weight Consumed (gram.)	Restraint	0.23	0.64	0.73	0.41	1.14	0.30
	Classification	**6.24**	**0.02**	0.01	0.97	0.28	0.61
	Meal Type	1.75	0.19	2.24	0.16	0.67	0.43
	Relation	0.37	0.55	0.25	0.63	0.32	0.58
	Number	0.09	0.77	0.32	0.58	0.13	0.72
	Location	2.17	0.15	0.02	0.90	0.39	0.54
	Time	0.01	0.91	0.83	0.38	0.01	0.96
	Duration	0.12	0.74	0.06	0.81	1.81	0.20
Energy Consumed (kcal.)	Restraint	0.57	0.46	1.71	0.21	0.16	0.70
	Classification	3.38	0.08	1.80	0.20	**5.27**	**0.04**
	Meal Type	1.89	0.18	**6.40**	**0.03**	0.04	0.85
	Relation	0.07	0.79	2.53	0.14	0.09	0.77
	Number	1.45	0.24	0.29	0.60	0.01	0.97
	Location	0.32	0.57	0.06	0.81	0.38	0.55
	Time	1.32	0.26	1.10	0.32	0.44	0.52
	Duration	0.27	0.61	1.02	0.33	2.03	0.18
Energy Consumed from CHO (kcal.)	Restraint	0.77	0.39	1.09	0.32	0.39	0.54
	Classification	1.27	0.27	0.03	0.86	2.69	0.13
	Meal Type	0.03	0.85	0.12	0.74	0.45	0.52
	Relation	0.29	0.59	0.14	0.72	0.26	0.62
	Number	**4.33**	**0.05**	0.00	0.96	**6.92**	**0.02**
	Location	3.22	0.08	0.12	0.73	3.92	0.07
	Time	0.22	0.64	0.01	0.92	0.06	0.81
	Duration	**5.65**	**0.02**	0.86	0.37	4.29	0.06
Energy Consumed from Fat (kcal.)	Restraint	1.05	0.31	0.88	0.37	0.15	0.71
	Classification	0.06	0.81	**4.74**	**0.05**	2.04	0.18
	Meal Type	0.01	0.97	1.93	0.19	0.51	0.49
	Relation	0.00	0.99	0.25	0.63	0.16	0.70
	Number	**6.91**	**0.01**	1.81	0.20	**4.89**	**0.05**
	Location	0.20	0.65	0.02	0.87	0.77	0.40
	Time	0.10	0.75	0.03	0.88	0.35	0.56
	Duration	2.92	0.10	1.68	0.22	4.33	0.06

Results and Significance of All Covariate Tests in ANCOVA Analyses, for all participants, for male participants only and for female participants only - Study 8, continued.

		All Participants		Males Only		Females Only	
Analysis	Covariate	Test t	p	Test t	p	Test	p
Energy Consumed from Protein (kcal.)	Restraint	0.02	0.88	0.20	0.66	1.10	0.31
	Classification	0.19	0.66	1.14	0.30	0.04	0.85
	Meal Type	0.01	0.91	0.83	0.38	0.36	0.56
	Relation	**5.31**	**0.03**	2.11	0.17	3.50	0.08
	Number	0.10	0.76	0.24	0.63	2.91	0.11
	Location	0.18	0.67	1.11	0.31	0.40	0.54
	Time	2.68	0.11	0.54	0.48	0.01	0.93
	Duration	0.33	0.57	1.19	0.30	0.99	0.34
Sweet Foods Consumed (gram.)	Restraint	0.55	0.46	0.27	0.61	1.34	0.27
	Classification	0.25	0.62	1.27	0.28	0.47	0.50
	Meal Type	0.07	0.79	0.16	0.69	0.21	0.66
	Relation	**5.93**	**0.02**	**5.84**	**0.03**	0.39	0.54
	Number	0.80	0.38	3.27	0.09	0.00	0.99
	Location	2.28	0.14	0.84	0.38	**5.06**	**0.04**
	Time	0.74	0.40	0.08	0.79	0.63	0.44
	Duration	1.15	0.29	3.57	0.08	0.04	0.85

APPENDIX 12.7: Correlation Coefficients for all Correlations between Energy Intake and all Environmental Stimuli per eating episode, for Male Participants - Study 8

Measure	WC Consumers			AC Consumers			NC Consumers		
	CC	N	p	CC	N	p	CC	N	p
Classificat'n	0.719	273	<0.001	0.698	256	<0.001	0.717	258	<0.001
Meal Type	0.550	83	<0.001	0.538	83	<0.001	0.568	88	<0.001
Relation	0.214	272	<0.001	0.356	239	<0.001[b]	0.182	257	0.003[b]
Number	0.305	242	<0.001[a]	-0.023	213	0.74[a]	0.151	243	0.02
Location	0.121	273	0.005[a]	-0.002	256	0.98[ab]	0.217	258	<0.001[b]
Start Time	0.168	272	0.005[a]	-0.043	245	0.51[a]	0.069	250	0.28
Duration	0.248	255	<0.001	0.180	242	0.005	0.077	231	0.24

[a b] denote significant differences between consumers

APPENDIX 12.8: Correlation Coefficients for all Correlations between Energy Intake and all Environmental Stimuli per eating episode, for Female Participants - Study 8

Measure	WC Consumers			AC Consumers			NC Consumers		
	CC	N	p	CC	N	p	CC	N	p
Classificat'n	0.659	285	<0.001	0.718	319	<0.001[b]	0.548	243	<0.001[b]
Meal Type	0.534	90	<0.001	0.533	85	<0.001	0.357	80	0.001
Relation	0.145	285	0.02	0.201	319	<0.001	0.171	241	0.01
Number	0.037	199	0.61	0.050	276	0.41	0.063	241	0.33
Location	0.072	285	0.23	0.119	319	0.03	0.174	243	0.006
Time	0.112	283	0.06	0.164	317	0.003	0.137	239	0.03
Duration	0.464	274	<0.001[a]	-0.005	294	0.93[ab]	0.339	233	<0.001[b]

[a b] denote significant differences between consumers

APPENDIX 12.9: The Proportion of Eating Episodes Initiated for All Reasons (% frequency) and the Results and Significance of All Analyses on All Participants - Study 8

		Consumer			
Measure	Sex	WC	AC	NC	Significance
Biological	M	24.0 (15.2)	13.7 (5.7)	27.0 (19.8)	F(g)(1,47)=0.72, p=0.67
	F	17.0 (10.4)	21.4 (15.1)	16.5 (7.1)	F(c)(2,47)=0.42, p=0.66
					F(gc)(2,47)=2.17, p=0.13
Cognitive	M	5.6 (4.1)	2.2 (1.9)	5.9 (4.4)	F(g)(1,47)=0.15, p=0.70
	F	3.6 (2.8)	5.6 (6.5)	6.0 (4.4)	F(c)(2,47)=0.97, p=0.38
					F(gc)(2,47)=1.60, p=0.22
Emotional	M	1.7 (1.5)	2.2 (4.0)	2.4 (4.7)	F(g)(1,47)=1.21, p=0.28
	F	0.7 (1.5)	5.8 (10.6)	5.2 (6.1)	F(c)(2,47)=1.21, p=0.31
					F(gc)(2,47)=0.76, p=0.48
Food Specific	M	20.8 (26.9)	10.3 (12.7)	16.7 (20.9)	F(g)(1,47)=0.03, p=0.87
	F	12.6 (14.2)	21.9 (25.4)	16.3 (15.6)	F(c)(2,47)=0.01, p=0.97
					F(gc)(2,47)=0.99, p=0.38
Situational	M	16.2 (10.9)	7.1 (6.1)	11.1 (11.3)	F(g)(1,47)=0.00, p=1.00
	F	8.6 (5.3)	15.9 (14.3)	9.9 (5.2)	F(c)(2,47)=0.16, p=0.85
					F(gc)(2,47)=3.01, p=0.06
Social	M	11.8 (7.4)	7.1 (6.4)	6.7 (5.2)	F(g)(1,47)=0.83, p=0.37
	F	8.2 (6.9)	12.5 (17.3)	12.4 (8.4)	F(c)(2,47)=0.01, p=0.99
					F(gc)(2,47)=1.23, p=0.30

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer.
F(gc) = Gender by Consumer Interaction.

APPENDIX 12.10: The Proportion of Eating Episodes Terminated for All Reasons (% frequency) and the Results and Significance of All Analyses on All Participants - Study 8

		Consumer			
Measure	Sex	WC	AC	NC	Significance
Biological	M	8.6 (5.8)	3.7 (3.9)	5.7 (7.6)	F(g)(1,47)=1.77, p=0.19
	F	7.0 (4.8)	13.0 (11.2)	6.0 (5.9)	F(c)(2,47)=0.56, p=0.57
					F(gc)(2,47)=2.77, p=0.07
Cognitive	M	4.5 (2.7)	8.4 (7.2)	19.0 (31.6)	F(g)(1,47)=0.16, p=0.69
	F	6.4 (13.3)	12.5 (22.2)	6.9 (8.5)	F(c)(2,47)=0.77, p=0.47
					F(gc)(2,47)=1.03, p=0.37
Emotional	M	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	F(g)(1,47)=2.65, p=0.11
	F	0.0 (0.0)	2.0 (4.4)	1.3 (3.5)	F(c)(2,47)=0.77, p=0.47
					F(gc)(2,47)=0.77, p=0.47
Food Specific	M	2.0 (3.1)	0.6 (1.2)	1.9 (3.5)	F(g)(1,47)=0.20, p=0.66
	F	0.6 (0.5)	4.2 (6.3)	0.9 (1.3)	F(c)(2,47)=0.53, p=0.59
					F(gc)(2,47)=2.82, p=0.07
Situational	M	22.2 (4.1)	18.3 (10.7)	26.9 (20.0)	F(g)(1,47)=0.26, 0.62
	F	19.7 (10.8)	24.4 (16.8)	17.6 (8.0)	F(c)(2,47)=0.04, p=0.96
					F(gc)(2,47)=1.43, p=0.25
Social	M	1.6 (1.3)	0.2 (0.5)	0.1 (0.3)	F(g)(1,47)=0.09, p=0.77
	F	0.6 (1.0)	0.4 (1.1)	0.6 (1.1)	**F(c)(2,47)=3.87, p=0.03**
					F(gc)(2,47)=2.54, p=0.09

F(g) = Main Effect of Gender; F(c) = Main Effect of Consumer.
F(gc) = Gender by Consumer Interaction.

APPENDIX 14.1: Results of Regression Equations for Subjective Measures of Appetite

Subjective Measures of Hunger

Hunger - R^2= 0.134, adj R^2= 0.065, F(7,88)=1.94, p=0.07

Regressor	Beta	significance
Sex	-0.095	0.45
Consumer - Sweet	0.137	0.29
Consumer - Energy	**-0.298**	**0.03**
Condition	0.052	0.60
B.M.I.	0.185	0.09
Restraint	-0.131	0.34
Tastiness	-0.058	0.59

Fullness - R^2= 0.121, adj R^2= 0.051, F(7,88)=1.73, p=0.11

Regressor	Beta	significance
Sex	-0.006	0.96
Consumer - Sweet	0.180	0.17
Consumer - Energy	0.051	0.70
Condition	0.143	0.16
B.M.I.	0.011	0.92
Restraint	0.224	0.10
Tastiness	0.127	0.24

Prospective Consumption - R^2= 0.119, adj R^2= 0.049, F(7,88)=1.70, p=0.12

Regressor	Beta	significance
Sex	-0.064	0.62
Consumer - Sweet	-0.023	0.86
Consumer - Energy	-0.001	0.99
Condition	-0.129	0.20
B.M.I.	0.034	0.75
Restraint	-0.263	0.06
Tastiness	-0.129	0.23

Subjetcive Measures of Thirst:

Desire to Drink - R^2= 0.197, adj R^2= 0.133, F(7,88)=3.08, p=0.006

Regressor	Beta	significance
Sex	-0.078	0.52
Consumer - Sweet	**0.388**	**0.003**
Consumer - Energy	**-0.378**	**0.004**
Condition	0.081	0.40
B.M.I.	0.114	0.28
Restraint	-0.114	0.38
Tastiness	-0.072	0.48

APPENDIX 14.2: Results of Regression Equations for Behavioural Measures of Appetite

Test Meal Intake - Weight of Food Consumed (gram.):
Dinner - R^2= 0.418, adj R^2= 0.372, F(7,88)=9.03, p<0.0001

Regressor	Beta	significance
Gender	**-0.273**	**0.01**
Consumer - Sweet	-0.071	0.51
Consumer - Energy	0.036	0.74
Condition	-0.080	0.33
B.M.I.	**0.358**	**0.0001**
Restraint	**-0.307**	**0.007**
Tastiness	0.068	0.44

Evening - R^2= 0.181, adj R^2= 0.116, F(7,88)=2.77, p=0.01

Regressor	Beta	significance
Gender	-0.219	0.08
Consumer - Sweet	-0.201	0.12
Consumer - Energy	0.026	0.84
Condition	-0.059	0.54
B.M.I.	0.189	0.08
Restraint	-0.088	0.50
Tastiness	0.133	0.20

At the End of the Day - R^2= 0.428, adj R^2= 0.383, F(7,88)=9.42, p<0.0001

Regressor	Beta	significance
Gender	**-0.361**	**0.0007**
Consumer - Sweet	-0.104	0.33
Consumer - Energy	0.036	0.73
Condition	-0.026	0.75
B.M.I.	**0.267**	**0.003**
Restraint	**-0.261**	**0.02**
Tastiness	0.147	0.10

Test meal Intake - Energy Consumed (kcal.):
Dinner - R^2= 0.329, adj R^2= 0.276, F(7,88)=6.16, p<0.0001

Regressor	Beta	significance
Gender	**-0.226**	**0.05**
Consumer - Sweet	-0.126	0.27
Consumer - Energy	-0.005	0.96
Condition	-0.083	0.35
B.M.I.	**0.359**	**0.0003**
Restraint	-0.224	0.06
Tastiness	0.116	0.22

Evening - R^2= 0.142, adj R^2= 0.074, F(7,88)=2.09, p=0.06

Regressor	Beta	significance
Gender	-0.171	0.18
Consumer - Sweet	-0.174	0.18
Consumer - Energy	0.090	0.49
Condition	-0.055	0.58
B.M.I.	0.182	0.10
Restraint	-0.124	0.36
Tastiness	0.073	0.50

At the End of the Day - R^2= 0.350, adj R^2= 0.299, F(7,88)=6.78, p<0.0001

Regressor	Beta	significance
Gender	**-0.327**	**0.004**
Consumer - Sweet	-0.163	0.15
Consumer - Energy	0.053	0.64
Condition	-0.056	0.52
B.M.I.	**0.274**	**0.005**
Restraint	-0.204	0.09
Tastiness	0.095	0.30

Proportion of All Macronutrients Consumed (%kcal.):
Carbohydrate:
Evening - R^2= 0.087, adj R^2= 0.014, F(7,88)=1.20, p=0.31

Regressor	Beta	significance
Gender	0.142	0.28
Consumer - Sweet	-0.160	0.24
Consumer - Energy	**0.285**	**0.04**
Condition	0.002	0.98
B.M.I.	-0.048	0.67
Restraint	0.007	0.96
Tastiness	-0.011	0.92

Fat:
Evening - R^2= 0.109, adj R^2= 0.038, F(7,88)=1.54, p=0.16

Regressor	Beta	significance
Gender	0.160	0.22
Consumer - Sweet	0.166	0.21
Consumer - Energy	-0.197	0.14
Condition	0.009	0.93
B.M.I.	0.002	0.98
Restraint	-0.269	0.05
Tastiness	**0.253**	**0.02**

At the End of the Day - R^2= 0.125, adj R^2= 0.055, F(7,88)=1.80, p=0.10

Regressor	Beta	significance
Gender	-0.025	0.84
Consumer - Sweet	0.252	0.06
Consumer - Energy	-0.261	0.05
Condition	0.086	0.39
B.M.I.	-0.004	0.97
Restraint	-0.268	0.05
Tastiness	0.212	0.05

Protein:

Dinner - R^2= 0.133, adj R^2= 0.064, F(7,88)=1.93, p=0.07

Regressor	Beta	significance
Gender	0.150	0.24
Consumer - Sweet	0.106	0.42
Consumer - Energy	0.157	0.23
Condition	0.006	0.95
B.M.I.	0.076	0.49
Restraint	-0.081	0.55
Tastiness	**-0.250**	**0.02**

Evening - R^2= 0.066, adj R^2= -0.009, F(7,88)=0.88, p=0.52

Regressor	Beta	significance
Gender	0.103	0.43
Consumer - Sweet	-0.116	0.39
Consumer - Energy	-0.134	0.33
Condition	0.087	0.40
B.M.I.	0.171	0.13
Restraint	-0.110	0.43
Tastiness	-0.039	0.73