Understanding the Determinants of Healthy and Unhealthy Eating Behaviour: An Application of Temporal Self-regulation Theory

By:

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Summary of Thesis

Chronic non-communicable diseases, such as obesity, diabetes, cancer, and cardiovascular disease pose a significant global burden in term of disability, mortality, and associated economic costs. Chapter 1 reviews evidence for link between diet and health, and argues that ensuring that individuals are eating healthfully (i.e., a higher proportion of foods that are conductive to health and a low proportion of foods that are not conductive to health) is a key strategy to improve public health. Recent government guidelines in the United Kingdom (where the sample population for the studies in this thesis is drawn from) are outlined and it is highlighted that current consumption does not match recommendations for health, and therefore, it is necessary to build more effective interventions to reverse consumption trends.

Chapter 2 provides a brief background and evaluation of the use of theoretical models in describing, predicting and explaining dietary behaviour. In light of the limitations of traditional social cognitive models, Temporal Self-Regulation Theory (TST) is discussed as a theoretically promising alterative, but gaps in the evidence base are identified.

Chapter 3 presents the first study in the thesis. It is composed of a pilot study and prospective survey. The pilot study investigated the expected outcomes of fruit and vegetable (F&V) consumption and unhealthy snacking for the target population and explores their perceptions of cues in the environment that increase or decrease the likelihood of enacting the target behaviour. The results of this pilot study were used to develop measures used in the main study. Study 1 found that the constructs identified by TST significantly predicted eating intentions and behaviour for consuming healthy and unhealthy foods, however, contrary to expectations, the capacity to self-regulate (operationalised by the Brief Self-Control Scale) did not significantly explain variance in either behaviour. This suggested that TST may be a useful framework for understanding the determinants of healthful eating; however, further

research is required to extend the findings using a different measure of self-regulatory capacity.

Chapter 4 presents a study that aimed to investigate how different measures of self-regulatory capacity relate to eating behaviour. The chapter begins with a discussion of the different ways in which researchers have conceptualised and measured self-regulatory capacity as level of self-control or specific executive functions. Study 2 tested how well unhealthy eating (which can be thought of as a self-regulation dilemma) could be predicted by multiple measures of self-regulatory capacity; conceptualised as a global ability or specific cognitive functions, and assessed via self-report or objective methods. In addition, self-report and objective measures of chocolate consumption were administered in order to explore if measurement congruence influenced the statistical strength of the relationship between self-regulatory capacity and unhealthy eating. None of the measures of self-control were significantly correlated to measures of food consumed for the sample as a whole. For individuals with high intentions to avoid high calorie snacks, scores on an objective measure of switching (a dimension of excutitive functioning) were correlated with unhealthy eating such that those who were less flexible ate less chocolate in the past week. Overall, these findings were contrary to predictions based on TST and theories of self-regulation, which propose that the capacity self-regulate is important for avoiding unhealthy behaviour.

After conducting Study 2, it was concluded that further research was necessary to synthesise current research findings and to (i) establish the strength of the relationship between self-regulatory capacity and healthful eating, and (ii) identify moderators of this relationship. Chapter 5 presents a systematic review and meta-analysis of the correlation between measures of self-regulatory capacity (which were broadened from self-control, executive function and delay of gratification, to include impulsivity and conscientiousness) and food consumption. Data from 120 studies and over 77,000 participants showed a

significant, small, positive correlation indicating that those with better capacity to self-regulate ate more healthfully (i.e., a higher quantity of healthy foods and/or lower quantity of unhealthy foods). The aspect of self-regulatory capacity moderated the relationship between self-regulatory capacity and food consumption, as did the type of measure (i.e., self-report or objective) of self-regulatory capacity.

The final chapter (6) reviews the main findings in this thesis, including that behaviour appears to be directed by both automatic and reflective processes in line with TST and dual process theories. However, the contribution of these processes is not consistent across different eating behaviours and contexts, and these variations warrant further investigation. Overall, future directions for research and interventions are suggested to enable a better understanding of the determinants of food consumption patterns and develop interventions to reverse current unhealthy eating trends.

Publications Relating to this Thesis

The following publication is related to Section 3.2 of this thesis. The order of authorship indicates the degree of contribution.

Evans, R., Norman, P., & Webb, T. (2017). Using temporal self-regulation theory to understand healthy and unhealthy eating intentions and behaviour. Appetite, 116, 357-364. doi:10.1016/j.appet.2017.05.022

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Appendix 3A: Free-responses to the belief elicitation study in Chapter 3

What are the immediate or short-term (i.e. while eating or shortly after) negative outcomes of you eating fruit and vegetables?		
ID	**Code/s**	**Response**
R1	0	nothing
R2	0	
R3	1	less filling than less healthy, stodgier foods
R4	U	Feel good for eating healthy food
R5	1	get hungry quickly, have to take time refill the fridge
R6	1, 2	Might not be so tasty, not quite so filling
R7	2	Might not enjoy the taste if certain fruit veg but eat them just for the nutritional benefits
R8	1	Not filling
R9	0	None
R10	U	Possible spike in blood sugar from fruit?
R11	0	None that I am aware of
R12	0	none
R13	1	Not always feeling full
R14	3	If I eat too much soft fruit and vegetables it can effect my digestive system/ bowel movements
R15	1	Sometimes don't feel so full compared to a high carb less vegetable meal
R16	1	Sometimes not very filling in their own
R17	1, 4	Not satisfying craving for unhealthy snacks, not filling enough
R18	U	Possibly mess to clean up - fruit juices or raisin/grape bits etc
R19	2	I do not like the taste of some e.g. asparagus
R20	U	sweet tooth, makes me want more sweet food
R21	3	Some fruits and vegetables may give me a stomach ache due to chronic digestive problems.
R22	0	None
R23	1	Feeling hungry not long after eating them that may cause the reverse desired effect of eating healthy by eating more often "to fill the void".
R24	4	Although I know the benefits of eating fruit and veg I sometimes feel dissatisfied after eating them. For example, a banana is a healthy snack but sometimes you just feel better if you have a Mars Bar!
R25	3	sometimes my stomach gets too acidic after eating fruit, so I feel a bit sick
R26	0	I don't think there are any.
R27	**U**	Mostly none, except very high sugary / GM sweeten fruits, or citrus fruits where I can sometimes become concerned about tooth decay. Especially when I have no water or something else (such as milk/cheese) to reduce / neutralise the acidity in my mouth.

Note. 1 = feelings of hunger or not feeling full, 2= unenjoyable or bad taste, 3= digestive problems, 4= not satisfying (cravings)

What are the immediate or short-term (i.e. while eating or shortly after) positive outcomes of you eating fruit and vegetables?		
ID	**Code/s**	**Response**
R1	1	i like the taste
R2	2	I feel full but not bloated like i would if i had eated carb heavy meals.
R3	4, 5	feel happy to be snacking healthily, more energy
R4	2	Satisfied a hunger
R5	4	focus better, motivation to not leave work to tomorrow
R6	4, 5	No sudden energy drop/slow release energy, Feel Good
R7	3, 4	Pleasure, feel healthy/nourished
R8	1	tastes good
R9	1, 3	Easy to eat, taste, healthy
R10	3, 5	Vitamins, gives an immediate immune system boost? Makes you feel more healthy? **5,**
R11	4	They make you feel good. They generally do not have any of the short term negative effects associated eating unhealthy snacks, ie, sickness, being bloated etc
R12	5	Better nutrition and digestion.
R13	4	Feel good about myself. Ensured they didn't go off, which means they were not a waste of money
R14	4	I enjoy eating fruit and veg.
R15	3, 5	At least a feeling of starting to be healthier, better digestion etc
R16	3, 5	More energy, happy to be healthy
R17	3, 4	Feel healthier and refreshed, happy because ive eaten well
R18	4, 5	Good feeling Healthier sugar boost
R19	4	Can feel rewarding
R20	1, 2	taste not hungry
R21	4	Feeling good about choosing to eat fruit and vegetables.
R22	1, 5	Tasty snack/meal Increased energy
R23	5	Sensation of "lightness" after eating fruit and vegetables (e.g. instead of carbs and meat). Faster digestive.
R24	3, 4	I usually feel good because I know that fruit and veg is good for me and they are helping me to stay healthy.
R25	2, 4, 5	Energy, the positive feeling of having eaten something good, less hungry
R26	3	They provide a good source of vitamins and minerals - and are part of a healthy diet.
R27	3, 5	Boost of energy - sugar. Feel "healthier, better" for having one of my 5 a day.

Note. 1 = likeable tastes, 2= feeling full or satisfied, 3= feeling healthy, 4= mental health benefits, 5= physical health benefits

What are the non-immediate (i.e. a long time after) negative outcomes of you eating fruit and vegetables?		
ID	**Code/s**	**Response**
R1	0	none
R2	1	It depends on the quantity of fruit and vegetables consumed. Large quantaties could cause bowel problems. Ortherwise I percieve no negative outcomes of eating fruit and vegetables.
R3	0	none
R4	2	Still not really full, want to eat more.
R5	2	don't have as much as satisfactory as eating unhealthy food, get hungry quicker
R6	0	None
R7	3	If you eat too much fruit, the high sugar content could be bad for you
R8	2	Not filling
R9	0	None
R10	0	Are there any? I can't think of any.
R11	U	To see the long term positive outcomes, they generally have to be used as part of a balanced diet, ie, with sufficient protein.
R12	0	none
R13	0	Nil
R14	0	None
R15	0	I can't imagine there are many long term negatives
R16	3	Some fruit is high in sugar?
R17	0	I can't think of any
R18	1	Pooping too much No real big issues of eating fruits and vegetables.
R19	3, 4	Too much fruit can result in too much sugar, could cause teeth problems etc.
R20	0	
R21	0	I have not had negative long-term outcomes of eating fruits and vegetables
R22	4	Acid damage to teeth from eating fruit
R23	0	None
R24	U	Fruit and veg, especially more exotic kinds, is quite expensive (more expensive than I think it should be)
R25	0	none
R26	0	Fruit and vegetables contain a good source of vitamins and minerals essential for health. I don't see any negative outcomes for eating fruit and vegetables.
R27	0	None, assuming the consumptions is apart of a balanced diet.

Note. 1= Bowel problems, 2= hunger or the desire to eat more, 3= high sugar consumption, 4= dental problems

What are the the non-immediate (i.e. a long time after) positive outcomes of you eating fruit and vegetables?		
ID	**Code/s**	**Response**
R1	1	keeps you healthy
R2	1	It depends on the quantity of fruit and vegetables consumed. Hopefully it will make me healthier
R3	1, 2, 3	healthier overall, lose weight (compared to eating unhealthy snacks), better skin **3**
R4	1	Feel healthy. Enjoyed eating them.
R5	4	better feeling about having health diet **,** Better mood, Better quality of life
R6	1, 2, 3	Good skin, Less likely to encounter health problems, Less wieght gain
R7	1	Getting the vitamins and minerals your body needs to work properly, which improves your general health
R8	1	Feeling healthy
R9	1	Feeling healthy
R10	1	Longer life, preventing cancer, lower chance of becoming ill due to a healthy body/immune system.
R11	1, 2	They will help you in losing weight if that is your aim, otherwise, they will just supplement a healthy lifestyle. They maintain a healthy heart and low cholesterol among other things.
R12	1, 3	Better health, better skin, fewer vitamin deficientcy based diseases
R13	1	I feel healthier
R14	1, 2	I am healthier and slimmer
R15	1, 2, 3, 5	Healthier lifestyle slimmer fitter (by this I mean gym workouts are more sustainable and the 'lifestyle' ideal is kept continuous) and stronger, better digestive system, also much better skin
R16	1, 2	Healthy diet, less likely to get fat
R17	1, 2, 4	Getting the right amount of vitamins and minerals, feeling better in myself and healthier, no guilt about eating unhealthily, not so much weight gain
R18	1, 2	Healthier lifestyle + diet Trimmer figure due to less fat intake Cheaper - fruits and vegetables are often priced lower (in weight) compared to snacks and treats
R19	1	Healthy lifestyle, cleaner insides.
R20	5	better faeces
R21	1, 4	Better mood and higher satisfaction with what I eat. Feeling healthier.
R22	1, 3	Vitamin C - provides a balanced diet and helps keep me healthy - better nails, hair etc
R23	1, 3, 6	Higher intake of vitamins that may relate to better skin, sleep regulation, better immune system, feeling of higher energy levels.
R24	1, 2	I know there are long-term health benefits of eating fruit and veg, in-fact, I think this is the main benefit e.g helping to maintain a health weight, and providing a source of vitamins and fibre to keep the body healthy
R25	1, 6	Having more energy, being healthier, provide nutrients and vitamins to my body
R26	1, 4	The positive outcomes of eating fruit and vegetables are they provide a good source of nutrients essential for health and well being.
R27	1, 4	Better well-being resulting in greater physical and mental health. Lower risk of diseases / complications.

Note. 1= Feeling healthier or better health, 2= weight loss or a slim body, 3= better skin, hair and nails, 4= Mental health and wellbeing, 5= Better digestion, 6= Higher energy levels

What factors and circumstances make it easier or enable you to eat fruit and vegetables?		
ID	**Code/s**	**Response**
R1	U	Offers in supermarkets/cafes for a healthy option
R2	1, 3, 4,	I have a large stock of fruit and veg at home. It is cheaper than processed foods and tasty!
R3	3	they aren't particularly expensive and I feel good about eating them
R4	2, 3	If it's cheap, available
R5	3, 5	when the shelf time is longer , relatively cheap, do not require too much time to cook, easy to wash, chop or prepare
R6	2	Commonly sold
R7	U	I think it's easier to eat more fruit and veg in summer, maybe because more of the food is in season or because you crave stodgy carbs less than in winter.
R8	3	Some are cheap
R9	2	Accessible
R10	5	I guess snack packs etc, such that the fruit is prepared for busy people.
R11	U	Knowing that they are good for me. Although they may not be nice, this encouragement makes their eating worthwhile
R12	2	They are readily available
R13	1	Seeing them in my fridge or them being my only option without spending more money
R14	3	Low price- especially fruit and veg that is in season
R15	0	Nil
R16	5	Pre prepared veg, less hassle
R17	3, 6	Cooking meals from scratch, cheep student food and veg stalls, cooking myself rather than going out, not being tired, having plenty of time to prepare meals/not being in a rush
R18	4, 7	Desire to be healthier General appreciation of the taste of fruit
R19	1, 6	If I am able to do regular food shops to keep stocked up and have time to plan and cook proper meals
R20	2	stocked in my local shop
R21	2, 3, 8, 9	My upbringing (mum always encouraging to eat fruit and vegetables), having a F&V store near where I live and being able to afford them. Finding recipes online.
R22	U	Being able to buy loose vegetables/ fruit so I can purchase the exact amount I'd like.
R23	1, 2, 8	Having fruit at hand for snacks, instead of processed sweet snacks. Having recipes at hand to try new combinations/flavours. Having a fruits and veggie store near the house (often, fruits and vegetables are not very good in supermarkets).
R24	7, 9	I usually have a snack around 11am and 4pm where I try and aim to eat a piece of fruit. Doing this at a certain time helps this become part of a routine. Sometime it requires imagination to prepare veg in an exciting way - if someone does this for me, it make it much easier!
R25	2, 3	If they are not too expensive, if they are of a good quality, if they are easily available
R26	9	I am vegetarian - so fruit and vegetables are an essential part of my daily food intake.
R27	U	I like them!

Note. 1= having them at home, 2= Easy or wide availability, 3= Cheap/ affordable, 4= Nice taste, 5= Convenience, 6= Having time to prepare and/ or cook, 7= Intention or desire to eat healthy/ fruit and vegetables, 8= Having recipes, 9= Upbringing and habits

What factors and circumstances make it difficult or prevent you from eating fruit and vegetables?		
ID	**Code/s**	**Response**
R1	1	Difficult to eat a range when a lot of fruit or unusual vegetables are expensive
R2	2	Sometimes I just want to eat pizza & cookies.
R3	0	none
R4	1, 3	Sometimes quite expensive, a lot of effort to make a decent snack**.**
R5	0	
R6	1, 3	quite high price, More hassle to prepare**,**
R7	3	Maybe takes more preparation time, so if I'm busy it's easier to get something like a sandwich than making a salad
R8	1	Expense for more exotic or out of season ones
R9	4	Having to eat them within a shorter time frame before it goes off
R10	3	Time and effort. Sometimes I just feel like it takes a lot of effort to eat healthy.
R11	1	They are often expensive, particularly with fruit/veg not native to the UK. They should be subsidized to encourage their eating.
R12	3	I'm lazy to eat them regularly
R13	1, 4	Forgetting about them and they go off... Price sometimes
R14	4	Forgetting that I brought the fruit or veg. For example, I have several gone off bananas in my cupboard that I keep forgetting about and now that they are very ripe I'm less inclined to eat them
R15	1, 2	Cost is an obvious one, however not true of all vegetables, however sometimes it's a case of remembering to eat them as I don't enjoy them as much as a slice of cake
R16	3, 4	Not having any / the ones I have going mouldy quickly , too lazy to cook **4, 3**
R17	1, 3, 4	Exam/busy times, not being able to use the whole vegetable (eg a whole lettuce is difficult to use up before it goes off, but buying a whole lettuce is cheeper than buying the right amount in a bag), being tired, not being able to shop during the week so ruit goes off and at the end of a week it's harder to eat fruit in particular, cost of some fruits and veg (eg berries can be expensive)
R18	1 3, 4	Availability - either you buy in bulk or buy one portion for five times the price Some are more difficult to eat than standard snacky foods Knowledge that they wont last as long Easily damaged - somewhat inconvenient. Especially when taking packed lunch o university, nobody wants mashed up banana on their university work.
R19	3	When I don't have time to prepare and cook balanced meals and only have time for a quick fix.
R20	1	price, quality
R21	2, 3	Personal preferences for tastier but less healthy foods. Difficulty to include diverse vegetable preparations when making a meal.
R22	3, 4	Prepackaged fruit/veg makes me more reluctant to buy as I know I will waste a great deal of the packet. I prefer to be able to pick the exact amount I know I'll eat - this isn't always available in store and if you shop online - but I don't always have th time to make a special trip to a greengrocers. Short shelf lives!
R23	1, 3	Find it somewhat expensive (compared to my country of origin). Requires more time for preparation compared to other pre-cooked meals. Some

		people may find it difficult to prepare them compared to other (oven ready) pre-cooked meals.
R24	1,	I'd say the cost sometimes prevents me. Apples and bananas are cheap but sometime you want something more exciting, but this can be expensive e.g berries and packaged fruit e.g M&S tend to be expensive
R25	2	If there is a choice between unhealthy snacks and fruit, I will most likely be more tempted to reach for the unhealthy first, because the craving for it is stronger
R26	0	None
R27	0	I enjoy eating fruit and vegetables and therefore personally do not have any difficulties in doing so. I daily consume the recommended 5-7 portions.

Note. 1= High price, 2= Wanting to eat unhealthy foods, 3= Preparation time and effort, 4= Produce spoiling

What are the immediate or short-term (i.e. while eating or shortly after) negative outcomes of you eating unhealthy snacks?		
ID	**Code/s**	**Response**
R1	**1**	I feel guilty and fat
R2	2	If i eat to much i feel sick
R3	1	guilt
R4	1	Feel fat, regret.
R5	1	Guilt of weight gain and ruining the healthy diet, Pimple
R6	3	sudden drop in energy if nothing else eaten
R7	1, 2	Feeling guilty, maybe feel a bit bloated
R8	0	Nothing
R9	0	None
R10	1, 2	Feeling guilty if I eat too many. Feeling overly full if I overindulge.
R11	2	They could make you feel ill if they contain too much sugar, caffeine etc..
R12	4	May stop you from eating your main meals properly
R13	1, 2	I feel bad about myself. Sometimes I feel sick
R14	3, 5, 6	Become tired or more hungry not long after. Crave more sugary foods
R15	5	I tend to eat a chain of unhealthy snacks after one as they come in bug packets and therefore tend to yoyo my nutrition
R16	2	Eating too much and feeling sick
R17	1, 4	Guilt for eating unhealthy snacks, not as hungry for meals
R18	1	Guilty feeling
R19	3	The drop after a sugar high, feeling thirsty after salty foods.
R20	1	feel guilty
R21	1	Sometimes I may feel guilty for eating them when I could have had something healthier.
R22	3, 6	Sugar rush/crash Doesn't fill you, so find yourself hungry shortly after
R23	0	
R24	3	The energy boost is sometimes short lived and at the back of your mind you know you cant have too many un-healthy snack. And I would certainly include biscuits as un-healthy snacks!!!
R25	2, 3	Bloated stomach, tiredness,
R26	0	None - I try not to eat them!!!!
R27	1	Feeling bad, guilt, for consuming it due to the negative health impact associated with unhealthy snacks, especially if the amount of associated calories has been seen.

Note. 1= Feelings of guilt or regret, 2= Feeling ill, overly full or bloated, 3= An energy drop or tiredness, 4= Disruption of main meals, 5= Crave or consume more unhealthy snacks, 6= More hungry

What are the immediate or short-term (i.e. while eating or shortly after) positive outcomes of you eating unhealthy snacks?		
ID	**Code/s**	**Response**
R1	1	I enjoy them
R2	3	I feel satisfied in a way only sugary fatty foods can manage!
R3	2, 3	taste good, satisfied hunger
R4	1, 2, 3	Feel full, enjoy the taste, had fun.
R5	1, 4	Satisfactory, pressure released, More energetic (especially with refreshment)
R6	2, 3, 4	-energy buzz/Sugar rush, -Taste nice, -filling
R7	1	Pleasure, maybe makes you feel better if you're eating for comfort
R8	2	Taste good
R9	1, 4	Satisfaction, reinvigorated, energy boost
R10	1, 2	I like the taste. I enjoy eating them/the taste makes me happy.
R11	1, 4	They make you happy!- A sugar rush for instance
R12	1, 2, 4	gives quick energy. Makes you feel happy to eat something that tastes nice and easy
R13	3	Fills the hunger void
R14	4	Increase in short term energy
R15	4	Sugar rush before the gym
R16	1	Feeling satisfied if you've craved something and then eaten it
R17	1, 3, 4	Stop me being hungry, give me quick energy, make me happy
R18	1, 2, 4	Instant sugar buzz Quick and easy and cheap Tasty – satisfaction
R19	1, 4	Sugar high, increased energy, satisfying a craving.
R20	2	quick, convenient, usually taste nice
R21	2, 3, 5	They are filling and very tasty. Can be shared with friends.
R22	1, 4	Satisfies a craving! Quick immediate energy boost (even though you know it won't last) Bit of a mood boost if it's a nice 'treat'
R23	3, 4	Sensation of being full right after eating. Sugar rush that comes after eating a sweet snack (the feeling of being more alert/awake).
R24	1, 2, 4	They taste great, tend to be readily available and cheap. They can really make you feel satisfied and give you an energy boost.
R25	1, 2, 3	the good taste, the feeling of comfort, the disappearance of hunger
R26	0	None - I try not toe eat them!!!!!
R27	1, 2, 5	While personally the negative effects outweighs the positives benefits, unhealthy snacks consumed in moderation (which hopefully is what I do! [sometimes]) allows you to enjoy life! Eliminating all unhealthy snacks would, personally, affect certain social interactions - not being able to enjoy some cake with friends etc. Also while guilt maybe associated with it, they has usually very tasty! And deliciousness wins over guilt.

Note. 1= Positive emotions, 2= Pleasant tastes, 3= Feeling full and satiated, 4= More energy or a sugar rush, 5= Positive social interactions

What are the non-immediate (i.e. a long time after) negative outcomes of you eating unhealthy snacks?		
ID	**Code/s**	**Response**
R1	1, 2	Will put on weight and damage heart
R2	1, 2	I will probably get fat and die of diabetes
R3	1, 2, 3	gain weight, poorer overall health, guilt
R4	3	Regret eating the snacks. Could have easily not done it.
R5	U	Want the snack even more
R6	1, 2	Bad skin/Acne, -Weight gain (if not eaten in moderation) -diabetes & many other health issues (if nit in moderation)
R7	1, 2	Weight gain, increase in cholesterol,
R8	3	Dissatisfied in diet
R9	4, 5	Feeling too full, disrupting meal patterns,
R10	1, 2	Weight gain/being higher than it should be, poor health, diabetes risk, risk of other health problems.
R11	1, 2	Poor health- gaining weight, dental/skin problems, heart problems
R12	1	You will gain weight more quickly if eated along with one's main meals
R13	2, 5	Get spots... Feel more sluggish
R14	1	Weight gain
R15	1, 3, 5	Weight gain and if you eat too unhealthily in a row sluggishness guilt and a bit of depression
R16	1, 2	Getting fat, maybe getting diabetes/high blood pressure etc
R17	1, 3	Weight gain, guilt about eating unhealthily
R18	1, 2, 3, 5	Guilty feeling Crash after energy buzz (if high in sugar content) Gain in weight Possible break outs on skin - due to fatty contents
R19	2	Increased sugars and salts could cause bodily problems e.g. heart, teeth, stomach etc.
R20	3, 4, 5	tired, feel groggy, ruins meal routines
R21	1, 2	Ingredients contained in unhealthy snacks may contribute to long-term health problems, such as deteriorating teeth and gaining fat.
R22	2, 5	Affects my teeth Feel lethargic if I've eaten too many (and not enough fruit/veg) Affects my skin – too many sweets leads to an outbreak!
R23		Higher blood glucose levels. Might mess the sleeping by the sugar intake for sustain periods during the day.
R24	1, 2	Health related reasons e.g put on weight, risk of things like diabetes
R25	1, 2	Weight gain, degenerated health, elevated blood pressure, water retention, digestive problems
R26	1	If I eat a lot of unhealthy snacks - ultimately I put on weight.
R27	1, 2, 3	Increased risk of obesity, and diseases (such as T2DM), with this comes reduced physical (and mental) well-being.

Note. 1= Weight gain or being overweight, 2= Physical health issues, 3= Negative feelings, 4= Disrupted meal patterns, 5= Feeling full and sluggish or tired

What are the non-immediate (i.e. a long time after) positive outcomes of you eating unhealthy snacks?		
ID	**Code/s**	**Response**
R1	0	None
R2	0	
R3	0	none
R4	1	Can remember how good it was when I ate the snacks.
R5	0	
R6	U	Might want to gain weight?
R7	0	cant think of any
R8	U	sugar can be satisfying
R9	3	Not hungry, delay mealtimes if busy
R10	4	Potentially a balanced diet if it were done in moderation? However it's not in my case, so I don't think there are any.
R11	0	There are none
R12	0	none.
R13	U	cheaper
R14	0	I can't think of any
R15	2	Tastes nice and it's often worth having something that tastes nice for the pleasure of eating it
R16	2, 4	Varied diet with some indulgence, so happier!
R17	2, 3	Full at the end of every day and not getting hungrier, happier, energy to be able to sustain busy and active lifestyle
R18	0	none
R19	0	none
R20	0	
R21	1	They may be related to having a good time with friends or family.
R22	0	None
R23	0	
R24	2	Sometime they just make you feel good and you enjoy it. Everything in moderation, as they say.
R25	0	there are no positive outcomes
R26	0	There are none for me.
R27	0	None for the long-term positive outcomes.

Note. 1= Positive memories, 2= A happier life, 3= Lack of hunger, 4= A balanced/ varied diet

What factors and circumstances make it easier or enable you to eat unhealthy snacks?		
ID	**Code/s**	**Response**
R1	1, 4	Having them around, having other people buy them, going to the shops with other people
R2	5	taste, ... **5**
R3	2, 3	they are generally cheaper and take little preparation
R4	2, 3	Cheap, easy, no hassle
R5	3, 6, 7	Not enough time or not willing to cook, feeling to chew on certain texture (e.g crisps), Negative mood
R6	2, 3, 4	Low price -No/little preparation -Basically everywhere sells them
R7	6	If it's a celebration, eg Christmas, birthdays, then it is more acceptable to treat yourself, if I've done a lot of exercise its easier to justify eating unhealthily
R8	2, 3	Cost and ease to eat on the go
R9	3, 4, 5	Too busy working to prepare food, availability, tasty
R10	3, 4	They're very accessible and are easier to fit into your bag etc compared with fruit. So it's just easy to pick one up to take with you. Doesn't take much time or effort.
R11	2	They are cheap- tax on them is far lower than it should be.
R12	3, 4	readily available and convinient
R13	2, 3	Laziness and price
R14	3, 4	If I am tired/ hungry and can't be bothered to cook. I have the items in the house
R15	2, 4	Cheap packet size promoted products in easy to access places in supermarkets
R16	2, 3, 5	Convenient and tastier than most healthy things, often cheaper too
R17	4	Easy availability, having small change **4**
R18	1, 3, 4	Vast availability and choice Quick to prepare and non-messy Popular to eat - people offer them around in social situations
R19	4, 7	When working at university, the shop is nearby so it's tempting to buy snacks.
R20	2, 4	stocked everywhere, cheap due to offers etc
R21	2, 4, 5	Easy access, affordable, good taste**. 4, 2, 5**
R22	4, 6	Mood- if I'm down, angry or upset I want an unhealthy snack - an apple is not going to fix it Availability, if i'm aware there's chocolate available I want to eat it
R23	4	Vending machines! Having spare change at hand for an unplanned buy.
R24	2, 4	They are very easily accessible and they are cheap. Habit is also crucial - sometime you get into bad ones.
R25	3, 4, 7	They are so easily available, the "lust" after them, when your blood sugar levels drop, easy to store or transport in bag
R26	6, 7	If I am out and about and need a quick boost to my energy levels - I an tempted to indulge in an unhealthy snack.
R27	1, 2, 6	If I'm having a bad day - comfort food! If compared to dried fruits / nuts then cost - unhealthy snacks on the whole I would say are cheaper than most dried fruits / nuts. Social events, particularly when alcohol is involved - no inhibitions with regards to healthy implications at those times

Note. 1= The presence of others, 2= Low price, 3= Convenience, 4= Wide availability and accessibility, 5= Taste, 6= Reasons to justify snacking, 7= Desire for unhealthy snacks

What factors and circumstances make it difficult or prevent you from eating unhealthy snacks?		
ID	**Code/s**	**Response**
R1	1, 2	Not having them in the house, taking my own lunch or snacks somewhere so i won't buy anything or have something off someone else
R2	4	cost, my health, not wanting to be sick
R3	3	I am on a diet so I am prevented because I rarely allow myself to eat unhealthy snacks
R4	0	None really
R5	4, 2	Think about the benefits of health eating / / have health food in the fridge which encourages me to cook
R6	4	want to be healthy
R7	1, 5	If there aren't any in the house, if you are with people who don't eat unhealthy snacks there is more pressure to avoid the unhealthy snacks
R8	0	none
R9	0	None
R10	1	Sadly not many do in my case. Unless I forget to take a snack.
R11	6	Knowing of the long term negative effects. Over indulging in them will potentially lead to health problems and gaining weight.
R12	6	Knowing that it is unhealthy
R13	8	Having to actively buy the product. Guilt
R14	7	Not buying unhealthy snacks
R15	0	Nil
R16	1	If I don't have any in the house
R17	1, 4	Not having any in the kitchen, lack of small change, trying to focus on improving my diet and waiting for meals, not walking past a shop on my way back from uni.
R18	1, 7, 6, 8	Simply dont buy them so that prevents me from eating them - always get the craving in the evening so if they're not in the house I cant have them The knowledge of how guilty i'll feel afterwards and knowing the long term effects and the desire for a healtier lifestyle will stop me from buying/eating them,
R19	1	When I am not near a shop or a shop is closed.
R20	0	nothing
R21	9	Thinking of other options that may be perhaps less tastier, or equally tasty, but healthier.
R22	2, 5, 6	If other people are enjoying healthy snacks around me The availability of an alternative healthy snack Directly after watching/hearing something that reminds me how bad they are (e.g. supersize vs superskinny)
R23	0	
R24	6	Health reasons - I know too much is not good for me.
R25	1, 2	If there is fruit and other healthy options of food available, if they are not available,
R26	3	If I am on a diet.
R27	2, 4, 6	Mostly none, however, I will [sometimes] choose a healthy snack over an unhealthy snack, which if done it will be due to the health implications associated with the unhealthy snacks that prevent me from eating it.

Note. 1= Lack of availability, 2= Alternative healthier options, 3= Self-control, 4= Desire to be healthy or avoid sickness, 5= Social pressure to avoid unhealthy snacks, 6= Knowledge of negative consequences , 7= Not buying unhealthy snacks, 8= Negative mental states

Table 3B.1.

Means, Standard Deviations and Correlations between TST Beliefs and Fruit & Vegetable Intake Intentions

		Connectedness Beliefs			Valence Beliefs			Temporality Beliefs		
		M	***SD***	***r* with intention**	***M***	***SD***	***r* with intention**	***M***	***SD***	***r* with intention**
ST NEGATIVE	Not feeling full	4.08	1.54	-.21*	3.02	1.05	-.05	2.29	1.62	.11
ST NEG	High sugar levels	3.72	1.49	.07	2.74	1.21	-.21*	3.28	1.85	-.09
LT NEG	Dental problems	3.12	1.53	-.08	1.98	1.16	-.08	5.56	1.58	.03
LT NEG	Bowel problems	2.52	1.36	-.08	2.00	1.13	-.04	4.11	1.92	.13
ST NEG	Bad taste	2.38	1.38	-.30***	2.67	1.12	-.07	2.79	2.45	.01
LT NEG	Digestive problems	2.36	1.21	.00	2.12	1.19	-.02	4.02	1.90	.09
ST POSITIVE	Feeling healthy	6.11	1.04	.30**	6.39	0.82	.20*	3.20	1.99	-.06
LT POS	Being healthy	5.87	0.95	.29**	6.49	0.90	.24**	5.09	1.79	-.04
LT POS	Physical health benefits	5.73	1.14	.31***	6.52	0.78	.09	4.23	1.66	-.29**
ST POS	Better quality of life	5.56	1.28	.46***	6.44	0.92	.23**	3.59	1.77	-.06
ST POS	Mental health benefits	5.29	1.31	.34***	6.40	0.97	.20*	3.63	1.72	-.04
LT POS	Weight loss	4.8	1.38	.24**	5.80	1.24	.16	5.98	1.21	-.02

*Note. *p < .05. * p < .01. *** p < .001.*

Table 3B.2.

Means, Standard Deviations and Correlations between TST Beliefs and Unhealthy Snacking Intentions

		Connectedness Beliefs			Valence Beliefs			Temporality Beliefs		
		M	***SD***	***r* with intention**	***M***	***SD***	***r* with intention**	***M***	***SD***	***r* with intention**
ST NEGATIVE	Guilt	4.76	1.73	-.36***	2.26	1.15	.17	2.62	1.57	.11
LT NEG	Weight gain	4.75	1.72	-.18*	1.95	1.14	.14	5.52	1.60	.17
LT NEG	Health issues	4.27	1.56	-.16	1.85	1.21	.07	5.96	1.51	.00
ST NEG	Feeling ill	4.27	1.65	-.21*	2.21	1.09	.21*	2.98	1.57	-.03
ST NEG	Negative feelings	3.79	1.78	-.36***	2.31	1.12	.20*	3.64	1.94	.18*
LT NEG	Energy drop	3.59	1.54	.00	2.64	1.05	.10	4.39	1.75	.10
ST POSITIVE	Pleasant taste	5.77	1.33	.21*	5.92	1.21	.23**	1.40	1.08	-.14
ST POS	Positive emotions	4.78	1.49	.30**	5.62	1.37	.24**	1.77	1.35	-.09
ST POS	Sugar rush	4.58	1.67	.09	4.52	1.38	.34**	2.23	1.66	-.05
LT POS	Positive memories	3.85	1.59	.07	5.30	1.40	.21*	3.00	2.06	-.08
LT POS	Happier life	3.74	1.53	.21*	5.31	1.60	.18*	3.07	1.94	-.01
LT POS	Balanced diet	2.59	1.36	.17	4.71	2.01	.03	4.87	1.73	-.06

*Note. *p < .05. * p < .01. *** p < .001.*

Appendix 5A: List of references of the primary studies included in the meta-analysis

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Appendix 5B: Coding manual

CODING SCHEME
Study details
Authors:
Study title + Year:
Publication type + Journal title *(if applicable):* *1. peer review journal* *4. unpublished thesis/ dissertation* *2. journal (not peer reviewed)* *5. unpublished data* *3. conference abstract*
How study was found: *0. other (please specify)* *3. email from the author* *1. database search (Dec 2016 or May 2018)* *2. reference of included paper*
Study number or subgroup within the study *(if multiple studies are reported within the same paper or data if provided for separate subgroups e.g. males / females, only health/ unhealthy foods eaten):*
Study design: *Was the measurement of self-regulatory capacity and eating behaviour…* *0. other (please specify)* *1. cross-sectional* *2. prospective* *3. manipulation e.g. experimental study (with SRA and food eaten both measured before or after the manipulation)*
Participant characteristics
***N*:**
Sample description: *who were the participants (e.g. undergraduate students, general population)*
Were the sample intending to control their food intake: *0. not reported* *1. yes (e.g. trying to eat healthier, eat less snacks or on a diet)* *2. no* *3. restrained eaters (i.e. intending to restrict food intake deliberately in order to prevent weight gain or to promote weight loss, measured by a specific 'restraint' scale)*
Level of hunger: *0. not measured and/or reported* *1. low mean (below mid-point) or preload/manipulation to reduce hunger* *2. average hunger (mean at mid-point on the scale)* *2. high mean (above mid-point)/ manipulation to increase hunger*
% female:
Age: *mean, range and/or SD*
BMI: *mean, range and/or SD*
Country of study: *if not reported in the text write 'NR' + (country i- where ethical approval was granted or ii- the institution of the first author)*

Self-regulatory ability (SRA)
Name of measure *(+ reference if applicable): as reported by the authors (e.g. Brief-Self Control Scale, Stroop Task), if a specific name is not reported then answer with the name of the aspect of SRA measured (e.g impulsivity, conscientiousness)*
Aspect of SRA measured: *1. Self-control (e.g. Brief-Self Control Scale)* *2. Executive functioning (e.g. Stop-Signal Task)* *3. Impulsivity (e.g. Barratt Impulsivity Scale)* *4. Delay of gratification (e.g. Money Choice Questionnaire)* *5. Conscientiousness (e.g. Big 5 Inventory, conscientiousness scale)*
Scaling: *0. other (please specify)* *1. Higher score = better SRA* *2. Lower score = better SRA*
Reliability assessment: *0. cannot assess – if no reliability coefficient or details on the reliability of the scale has been reported* *1. good – reliability coefficient of .70 or above, reports the scale has been found reliable in previous research* *2. average – reliability coefficient of .60 to .69* *2. poor – reliability coefficient under .60*
Type of SRA measure: *1. self-report questionnaire (e.g. Brief SELF-Control Scale)* *2. objective performance (e.g. laboratory task measuring behaviour, reaction time etc)* *3. informant report questionnaire (e.g. Children's Behavior Questionnaire)*
Outcome (foods eaten) *Please name 'B1', 'B2', 'B3' etc if multiple food types have been analysed separately*
Behaviour: *What food stuffs were eaten or avoided? As described by the authors (e.g. fruit and vegetables, avoid saturated fat).*
Healthiness of the food consumed *(healthiness as reported by the authors, or following the examples in the coding scheme below if the healthiness is not explicitly reported)* *1. Healthy (including fruits, vegetables, or wholegrains)* *2. Unhealthy (including , foods high in refined sugar such as biscuits/ cookies, ice-cream, sweets/candy, pastries, cake, foods high in saturated fats such as crisps, margarine, fries, red meat, processed meat such as bacon and hamburgers, take-away or fast-food, such as pizza, and sugar sweetened beverages such as non-diet soda or energy drinks)* *3. composite (if the measure includes items reported by the authors to be 'healthy' and 'unhealthy' or includes both 'healthy' and 'unhealthy' foods cited in 1 and 2, or if no details of the specific foods consumed have been reported e.g. breakfast, snacks, or if the food is described by the authors as 'neutral').*

Food eaten assessment measure: *How was the outcome measured (e.g. diary, taste test, food frequency questionnaire, single item)?*
Scaling: *0. other (please specify)* *1. Higher score = healthier behaviour* *2. Lower score = healthier behaviour*
Type of measure of eating healthy and unhealthy foods: *1. self-report (e.g. Block rapid food screener)* *2. objective performance (e.g. taste test).* *3. informant-report (e.g. parents complete a food frequency questionnaire for their child)*
Results
Pearson's r: *report the r value, significance (using exact value if possible) and if any control variables were used*
Other statistical analysis methods: *report the name of the test, the value/s and significance (using the exact value if possible).*

Table 5C

Details of included studies

Author (year) group	N	Demographic information			Dietary goals		Self-regulatory ability		Food intake		Effect size (r)
		% F	M age (years)	M BMI (kg/m^2)	Diet goals	Hunger	Category	Measure (type)	Behaviour	Measure (type)	
Adams et al. (2014) Study 3	176	91.70	21.80	24.42	Restrained	Av	Cons	BFI-44 (SR)	Healthy	Taste test (Obj)	.07
	176						Cons	BFI-44 (SR)	Unhealthy	Taste test (Obj)	.26
	154						Imp	UPPS pers (SR)	Healthy	Taste test (Obj)	.05
	154						Imp	UPPS pers (SR)	Unhealthy	Taste test (Obj)	-.04
	160						Imp	UPPS premed (SR)	Healthy	Taste test (Obj)	.08
	160						Imp	UPPS premed (SR)	Unhealthy	Taste test (Obj)	-.03
	175						SC	BSCS (SR)	Healthy	Taste test (Obj)	-.02
	175						SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.04
Adams et al. (2017) Study 1	129	93.30	23.07	24.68	Restrained	Av	Cons	BFI-44 (SR)	Unhealthy	Taste test (Obj)	-.01
	105						Imp	UPPS pers (SR)	Unhealthy	TasteTest (Obj)	-.05
	109						Imp	UPPS premed (SR)	Unhealthy	Taste test (Obj)	-.05
	132						SC	BSCS (SR)	Unhealthy	Taste test (Obj)	-.06
Adriaanse et al. (2014)	77	92.00	21.30	22.10	Yes	NR	SC	BSCS (SR)	Healthy	FF diary (SR)	-.06
	77						SC	BSCS (SR)	Unhealthy	FF diary (SR)	.30
Alexander (2014) Study 1	131	100	NR	NR	NG	NR	EF	Reading + spatial span (Obj)	Healthy	FFQ (SR)	.03
	131						EF	Reading + spatial span (Obj)	Unhealthy	FFQ (SR)	.01

Allan et al. (2010)	62	90.30	20.40	22.60	Yes	NR	EF	Stroop (Obj)	Unhealthy	Taste test (Obj)	.48
	62						EF	Fluency (Obj)	Unhealthy	Taste test (Obj)	.39
	62						EF	Tower (Obj)	Unhealthy	Taste test (Obj)	.22
Allen et al. (2015)	9160	52.50	43.87	NR	NR	NR	Cons	Mini Marker (SR)	Healthy	Q 2 F/V (SR)	.11
Allom & Mullan (2012)	209	75.10	20.06	NR	NR	NR	EF	IGT (Obj)	Healthy	FFQ (SR)	.03
	209						EF	ToH (Obj)	Healthy	FFQ (SR)	.04
Allom & Mullan (2014)	115	72.20	19.79	NR	Yes	NR	EF	SST (Obj)	Healthy	FFQ (SR)	.03
	115						EF	SST (Obj)	Unhealthy	FFQ (SR)	.27
	115						EF	Stroop (Obj)	Healthy	FFQ (SR)	.01
	115						EF	Stroop (Obj)	Unhealthy	FFQ (SR)	.30
	115						EF	N-back (Obj)	Healthy	FFQ (SR)	.20
	115						EF	N-back (Obj)	Unhealthy	FFQ (SR)	-.12
	115						EF	Ospan (Obj)	Healthy	FFQ (SR)	.28
	115						EF	Ospan (Obj)	Unhealthy	FFQ (SR)	-.03
Allom & Mullan (2015) Study 1	82	80.49	20.40	22.62	Yes	NR	EF	Stroop (Obj)	Healthy	FFQ (SR)	-.05
	82						EF	Stroop (Obj)	Unhealthy	FFQ (SR)	0.20
Allom & Mullan (2015) Study 2	78	78.21	22.97	23.11	NR	NR	EF	Stroop (Obj)	Healthy	FFQ (SR)	-.01
	78						EF	Stroop (Obj)	Unhealthy	FFQ (SR)	.02
Arad (2006)	118	100	64.00	NR	NR	<	Cons	NEO-PI (SR)	Composite	FFQ (SR)	-.10
Bennett & Blissett (2016)	92	43.20	2.46	NR	NR	NR	EF	Tower Turns (Obj)	Composite	Meal consump (Obj)	-.10
	92						Imp	ECBQ (IR)	Composite	Meal consump (Obj)	-.02
	92						Imp	Line Walk (Obj)	Composite	Meal consump (Obj)	.05

Berg et al. (2014) White	1049	100	NR	NR	NR	NR	Cons	TIPI (SR)	Healthy	Q 2 F/V (SR)	-.01
Berg et al. (2014) Black	1083	100	NR	NR	NR	NR	Cons	TIPI (SR)	Healthy	Q 2 F/V (SR)	.49
Bogg (2008)	201	49.25	19.46	23.51	No	NR	Cons	Big5 AC (SR)	Composite	Questionnaire (SR)	.17
	201						Cons	Big5 AC (SR)	Healthy	Questionnaire (SR)	.08
Booker & Mullan (2013)	148	75.00	19.01	NR	NR	NR	EF	IGT (Obj)	Composite	Q 1 (SR)	-.05
	148						EF	IGT (Obj)	Healthy	Q 1 (SR)	-.09
	147						EF	Go/No-Go (Obj)	Composite	Q 1 (SR)	-.09
	147						EF	Go/No-Go (Obj)	Healthy	Q 1 (SR)	-.17
	150						EF	ToL (Obj)	Composite	Q 1 (SR)	-.18
	150						EF	ToL (Obj)	Healthy	Q 1 (SR)	-.12
Brace & Yeomans (2016)	80	100	NR	NR	NR	Av	DoG	DDT (Obj)	Unhealthy	Taste test (Obj)	-.02
	80						EF	Go/Stop (Obj)	Unhealthy	Taste test (Obj)	-.18
	80						Imp	Info Sampling (Obj)	Unhealthy	Taste test (Obj)	-.19
Brummett et al. (2008) Wives	850	100	43.10	23.10	NR	NR	Cons	NEO-PI-R (SR)	Composite	FFQ (SR)	.05
Brummett et al. (2008) Husbands	850	0	44.90	25.40	NR	NR	Cons	NEO-PI-R (SR)	Composite	FFQ (SR)	.02
Carrillo et al. (2012)	356	71.00	24.42	NR	NR	NR	Cons	BFI (SR)	Unhealthy	Q 1 (SR)	.11
	356						Cons	BFI (SR)	Healthy	Q 1 (SR)	.04
	356						Cons	BFI (SR)	Healthy	Q 1 (SR)	.06
Churchill et al. (2008)	315	65.71	38.50	24.89	NR	NR	Imp	UPPS pers (SR)	Unhealthy	FFQ (SR)	.19
	315						Imp	UPPS premed (SR)	Unhealthy	FFQ (SR)	.08

Churchill & Jesspop (2010)	256	79.36	33.05	24.06	NR	NR	Imp	UPPS pers (SR)	Unhealthy	Questionnaire (SR)	.20
	256						Imp	UPPS premed (SR)	Unhealthy	Questionnaire (SR)	.08
Churchill & Jessop (2011)	139	77.70	21.17	22.04	NR	NR	Imp	UPPS pers (SR)	Unhealthy	FFQ (SR)	.17
	139						Imp	UPPS premed (SR)	Unhealthy	FFQ (SR)	-.02
Clare et al. (2015) Control	27	85.20	70.22	29.22	NR	NR	EF	Fluency (Obj)	Composite	FFQ (SR)	.28
	27						EF	TMT (Obj)	Composite	FFQ (SR)	-.34
Collins & Mullan (2011)	190	78.00	19.70	NR	NR	NR	EF	Go/No-Go (Obj)	Healthy	FFQ (SR)	-.06
	190						EF	Go/No-Go (Obj)	Composite	FFQ (SR)	.02
Conner et al. (2017)	281	54.40	19.90	23.78	NR	NR	Cons	NEO-FFI (SR)	Healthy	Q1 diary	.15
Study 1	281						Cons	NEO-FFI (SR)	Unhealthy	Q1 diary	.04
	281						Cons	NEO-FFI (SR)	Unhealthy	Q1 diary	.12
	281						Cons	NEO-FFI (SR)	Healthy	Q1 diary	.03
Conner et al. (2017)	792	72.60	19.73	23.99	NR	NR	Cons	NEO-FFI (SR)	Healthy	Q1 diary	.13
Study 2	792						Cons	NEO-FFI (SR)	Unhealthy	Q1 diary	.07
	792						Cons	NEO-FFI (SR)	Unhealthy	Q1 diary	.15
	792						Cons	NEO-FFI (SR)	Healthy	Q1 diary	.18
Cukic et al. (2016)	3215	59.30	43.20	NR	NR	NR	Cons	NEO-PI-3 (IR)	Healthy	FFQ (SR)	.09
	3215						Cons	NEO-PI-3 (IR)	Composite	FFQ (SR)	.02
	3351						Cons	NEO-PI-3 (SR)	Healthy	FFQ (SR)	.12
	3351						Cons	NEO-PI-3 (SR)	Composite	FFQ (SR)	.02

Daugherty & Brase (2010)	467	62.74	18.99	NR	NR	NR	DoG	MCQ (Obj)	Composite	Q 1 (SR)	.13
deBruijn et al. (2005)	825	56.72	14.80	NR	NR	NR	Cons	GA100 (SR)	Healthy	FFQ (SR)	.09
	825						Cons	GA100 (SR)	Healthy	FFQ (SR)	.08
deBruijn et al. (2007)	208	61.50	15.20	NR	NR	NR	Cons	GA100 (SR)	Unhealthy	Q 1 (SR)	-.05
deBruijn et al. (2009)	405	57.53	60.25	NR	NR	NR	Cons	GA100 (SR)	Healthy	FFQ (SR)	.11
Desousky (2013)	162	75.90	21.64	NR	NR	NR	EF	BDS (Obj)	Healthy	FFQ (SR)	.11
	162						EF	BRIEF-A init (SR)	Healthy	FFQ (SR)	-.08
	162						EF	BRIEF-A inhib (SR)	Healthy	FFQ (SR)	-.40
	160						EF	Flanker (Obj)	Healthy	FFQ (SR)	.00
	162						EF	BRIEF-A shift (SR)	Healthy	FFQ (SR)	.25
	160						EF	Card sort (Obj)	Healthy	FFQ (SR)	-.04
	162						EF	BRIEF-A wm (SR)	Healthy	FFQ (SR)	-.25
Elliot (2013)	98	49.00	NR	NR	NR	NR	EF	Tempe sort (Obj)	Composite	Questionnaire (SR)	.22
	98						EF	Digit span b (Obj)	Composite	Questionnaire (SR)	-.01
Elliston et al. (2017)	61	68.90	32.33	24.97	No	NR	SC	BSCS (SR)	Healthy	Q 1 (SR)	.25
Ely (2013)	78	100	20.47	22.45	No	>	DoG	DDT (Obj)	Composite	Pre-load (Obj)	.09
	78						DoG	DDT (Obj)	Unhealthy	Taste test (Obj)	-.06
Evans et al. (2017) Healthy	133	68.40	23.92	NR	NR	NR	SC	BSCS (SR)	Healthy	Q 1 (SR)	.12

Evans et al. (2017) Unhealthy	109	72.80	23.10	NR	NR	NR	SC	BSCS (SR)	Unhealthy	Q 1 (SR)	.32
Evans et al. (2018)	118	69.5	22.23	23.21	NG	Av	DoG	DDC single (Obj)	Unhealthy	Q_2 (SR)	-.03
	118						DoG	DDC single (Obj)	Unhealthy	Q 1 (SR)	.12
	118						DoG	DDC single (Obj)	Unhealthy	Taste test (Obj)	-.06
	118						EF	BRIEF-A inhib (SR)	Unhealthy	Q_2 (SR)	.02
	118						EF	BRIEF-A inhib (SR)	Unhealthy	Q 1 (SR)	.07
	118						EF	BRIEF-A inhib (SR)	Unhealthy	Taste test (Obj)	.08
	118						EF	BRIEF-A shift (SR)	Unhealthy	Q_2 (SR)	.05
	118						EF	BRIEF-A shift (SR)	Unhealthy	Q 1 (SR)	.13
	118						EF	BRIEF-A shift (SR)	Unhealthy	Taste test (Obj)	.03
	118						EF	SwIFT (Obj)	Unhealthy	Q_2 (SR)	.07
	118						EF	SwIFT (Obj)	Unhealthy	Q 1 (SR)	.57
	118						EF	SwIFT (Obj)	Unhealthy	Taste test (Obj)	.00
	118						EF	BRIEF-A wm (SR)	Unhealthy	Q_2 (SR)	-.11
	118						EF	BRIEF-A wm (SR)	Unhealthy	Q 1 (SR)	.08
	118						EF	BRIEF-A wm (SR)	Unhealthy	Taste test (Obj)	.14
	118						EF	Ospan (Obj)	Unhealthy	Q_2 (SR)	-.07
	118						EF	Ospan (Obj)	Unhealthy	Q 1 (SR)	-.04
	118						EF	Ospan (Obj)	Unhealthy	Taste test (Obj)	.09
	118						SC	BSCS (SR)	Unhealthy	Q_2 (SR)	-.08
	118						SC	BSCS (SR)	Unhealthy	Q 1 (SR)	.06
	118						SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.08

Fay et al. (2015) Initiators	38	60.50	35.08	23.57	NR	<	Imp	BIS-11 motor (SR)	Unhealthy	Taste test (Obj)	.39
Fries & Hofmann (2009) Study 1	38	86.80	23.21	NR	NR	NR	SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.11
Garza et al. (2016)	478	69.00	42.00	27.1	NR	NR	DoG	DDT (Obj)	Unhealthy	Q 1 (SR)	.11
Gerrits et al. (2010)	511	46.0	16.30	NR	NR	NR	SC	BSCS (SR)	Unhealthy	FFQ (SR)	.18
	511						SC	BSCS (SR)	Healthy	Q 2 F/V (SR)	.23
Giese et al. (2015) Finland	825	53.00	12.76	NR	NR	NR	SC	BSCS (SR)	Healthy	Q 1 (SR)	.07
	825						SC	BSCS (SR)	Healthy	FFQ (SR)	.26
	825						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.15
	825						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.22
	825						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.28
Giese et al. (2015) Germany	1055	55.00	12.65	NR	NR	NR	SC	BSCS (SR)	Healthy	Q_1 (SR)	.16
	1055						SC	BSCS (SR)	Healthy	FFQ (SR)	.26
	1055						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.24
	1055						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.24
	1055						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.29
Giese et al. (2015) Romania	971	55.00	14.23	NR	NR	NR	SC	BSCS (SR)	Healthy	Q 1 (SR)	.09
	971						SC	BSCS (SR)	Healthy	FFQ (SR)	.18
	971						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.18
	971						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.19
	971						SC	BSCS (SR)	Unhealthy	FFQ (SR)	.22

Goldberg & Strycker (2002)	637	58.00	14.23	NR	NR	NR	Cons	NEO-PI-R (SR)	Composite	FFQ (SR)	.11
Goodwin et al. (2017)	1619	70.00	35.68	NR	NR	NR	Imp	BIS-11 short (SR)	Unhealthy	Questionnaire (SR)	.22
	1619						Imp	BIS-11 short (SR)	Healthy	Q 2 F/V (SR)	.20
Greenwood et al. (2014)	79	67.09	24.65	NR	NR	<	Imp	BIS-11 short (SR)	Unhealthy	Taste test (Obj)	-.03
Guerrieri et al. (2007)	38	100	19.30	22.2	NG	NR	EF	SST (Obj)	Unhealthy	Taste test (Obj)	.42
Hagger (2013) Study 2	83	54.21	19.00	NR	NR	>	SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.20
Hall et al. (2008) Study 2	121	77.70	22.24	NR	NR	NR	EF	Go/No-Go (Obj)	Healthy	FFQ (SR)	.18
Hall (2012)	207	75.20	45.20	NR	NR	NR	EF	Go/No-Go (Obj)	Unhealthy	FFQ (SR)	-.17
	207	75.20	45.20	NR	NR	NR	EF	Stroop (Obj)	Unhealthy	FFQ (SR)	-.23
Hankonen et al. (2014)	679	0	20.00	NR	NR	NR	SC	Questionnaire (SR)	Healthy	Q 2 F/V (SR)	.21
	679						SC	Questionnaire (SR)	Unhealthy	FFQ (SR)	.19
Hartman et al. (2012) Control	32	18.00	12.11	NR	NR	<	Imp	BIS adolescents (SR)	Unhealthy	Food Available (Obj)	-.16
Haws & Redden (2013) Study 3	81	25.0	NR	24.96	NR	<	SC	BSCS (SR)	Unhealthy	Food Available (Obj)	.08
Haynes et al. (2014)	124	100	20.45	22.81	Yes	2	SC	BSCS (SR)	Unhealthy	Taste test (Obj)	-.10
Haynes et al. (2015)	147	100	19.49	22.55	Yes	2	EF	Inhib SCS (SR)	Unhealthy	Taste test (Obj)	-.00

Haynes et al. (2016)	134	100	20.08	NR	Yes	NR	EF	Inhib SCS (SR)	Unhealthy	Taste test (Obj)	.27
	134						EF	Init SCS (SR)	Unhealthy	Taste test (Obj)	.22
	134						SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.28
He et al. (2014)	23	52.00	18.01	21.88	NR	<	EF	IGT (Obj)	Healthy	FFQ (SR)	.16
	23	52.00					EF	IGT (Obj)	Unhealthy	FFQ (SR)	-.13
Hofmann et al. (2008) Study 2	117	100	22.38	NR	NR	NR	EF	Ospan (Obj)	Unhealthy	Taste test (Obj)	-.12
Hofmann et al. (2009)	118	100	23.00	22.24	NR	NR	EF	SST (Obj)	Unhealthy	Taste test (Obj)	.06
	118	100					EF	Ospan (Obj)	Unhealthy	Taste test (Obj)	.02
Hunter et al. (2018) Study 1 Near	79	64.60	38.80	24.80	NR	<	EF	Stroop (Obj)	Unhealthy	Food Available (Obj)	.01
Hunter et al. (2018) Study 1 Far	80	62.50	38.00	24.70	NR	<	EF	Stroop (Obj)	Unhealthy	Food Available (Obj)	.03
Imhoff et al. (2014) Study 1 Control	69	84.00	22.16	NR	NR	NR	SC	SRQS (SR)	Unhealthy	Taste test (Obj)	-.21
Isasi & Wills (2011)	1771	51.00	13.90	NR	NR	NR	SC	(good) Questionnaire (SR)	Healthy	FFQ (SR)	.15
	1771						SC	(good) Questionnaire (SR)	Unhealthy	FFQ (SR)	.13
	1771						SC	(poor) Questionnaire (SR)	Unhealthy	FFQ (SR)	.31
	1771						SC	(poor) Questionnaire (SR)	Healthy	FFQ (SR)	-.05

Junger & van Kampen (2010)	196	52.23	16.78	21.12	NR	NR	EF	Raven PM (Obj)	Composite	Q_1 (SR	.02
	196						EF	Raven PM (Obj)	Composite	Q_1 (SR)	.18
	196						EF	Raven PM (Obj)	Healthy	Q_1 (SR)	.21
	196						EF	Raven PM (Obj)	Healthy	Q_1 (SR)	.06
	196						EF	Raven PM (Obj)	Unhealthy	FFQ (SR)	-.14
	199						EF	Corsi b (Obj)	Composite	Q_1 (SR)	-.10
	199						EF	Corsi b (Obj)	Composite	Q_1 (SR)	-.04
	199						EF	Corsi b (Obj)	Healthy	Q_1 (SR)	.07
	199						EF	Corsi b (Obj)	Healthy	Q_1 (SR	-.10
	199						EF	Corsi b (Obj)	Unhealthy	FFQ (SR)	.08
	199						EF	Corsi f (Obj)	Composite	Q_1 (SR	-.03
	199						EF	Corsi f (Obj)	Composite	Q_1 (SR)	.11
	199						EF	Corsi f (Obj)	Healthy	Q_1 (SR)	-.05
	199						EF	Corsi f (Obj)	Healthy	Q_1 (SR)	-.05
	199						EF	Corsi f (Obj)	Unhealthy	FFQ (SR)	-.12
	201						SC	SCS (SR)	Composite	Q_1 (SR)	.08
	201						SC	SCS (SR)	Composite	Q_1 (SR)	-.04
	201						SC	SCS (SR)	Healthy	Q_1 (SR)	.04
	201						SC	SCS (SR)	Healthy	Q_1 (SR)	.02
	201						SC	SCS (SR)	Unhealthy	FFQ (SR)	-.12
Kakoschke et al. (2015)	144	100	20.20	22.90	NR	>	Imp	BIS-11 att (SR)	Unhealthy	Taste test (Obj)	.14
	144						Imp	BIS-11 motor (SR)	Unhealthy	Taste test (Obj)	.19
	144						Imp	BIS-11 nonplan (SR)	Unhealthy	Taste test (Obj)	.07
Kakoschke et al. (2017) Control	40	100	20.16	23.12	NR	<	Imp	BIS-11 (SR)	Healthy	Taste test (Obj)	-.15
	40						Imp	BIS-11 (SR)	Unhealthy	Taste test (Obj)	.21

Keller & Siegrist (2015)	951	50.79	56.00	24.63	NR	NR	Cons	NEO-FFI (SR)	Unhealthy	FFQ (SR)	.02
	951						Cons	NEO-FFI (SR)	Unhealthy	FFQ (SR)	.01
	951						Cons	NEO-FFI (SR)	Healthy	FFQ (SR)	.08
	951						Cons	NEO-FFI (SR)	Unhealthy	FFQ (SR)	.03
	951						Cons	NEO-FFI (SR)	Healthy	FFQ (SR)	.05
Keller et al. (2016)	2644	54.00	58.62	24.16	NR	NR	SC	BSCS (SR)	Composite	FFQ (SR)	.13
Kikuchi et al. (1999) Male	356	0	18.90	21.70	NR	NR	Cons	NEO-PI-R (SR)	Composite	Questionnaire (SR)	.102
Kikuchi et al. (1999) Female	357	100	18.60	20.60	NR	NR	Cons	NEO-PI-R (SR)	Composite	Questionnaire (SR)	.08
Kikuchi & Watanabe (2000) Male	76	0	21.10	22.30	NR	NR	Cons	NEO-FFI (SR)	Composite	FFQ (SR)	.00
Kikuchi & Watanabe (2000) Female	394	100	20.80	20.60	NR	NR	Cons	NEO-FFI (SR)	Composite	FFQ (SR)	.02
Kirschenbaum & Dykman (1991) Restrained	40	100	NR	NR	Restrained	<	SC	SC Schedule (SR)	Unhealthy	Taste test (Obj)	-.40
Kirschenbaum & Dykman (1991) Unrestrained	40	100	NR	NR	No	<	SC	SC Schedule (SR)	Unhealthy	Taste test (Obj)	.10
Kliemann et al. (2016)	923	58.00	NR	NR	NR	NR	SC	BSCS (SR)	Healthy	Q 2 F/V (SR)	.27
	923						SC	BSCS (SR)	Unhealthy	Questionnaire (SR)	.21
	923						SC	BSCS (SR)	Unhealthy	Questionnaire (SR)	.26

Kye et al. (2012)	1530	50.10	46.70	NR	NR	NR	Cons	TIPI (SR)	Composite	Q 1 (SR)	.07
	1530						Imp	BIS (SR)	Composite	Q 1 (SR)	.04
Larsen et al. (2012)	109	100	20.94	21.61	Yes	>	Imp	BIS-11 (SR)	Unhealthy	Taste test (Obj)	.03
Limbers & Young (2015)	240	82.50	19.03	NR	NR	NR	EF	BRIEF-A init (SR)	Healthy	Q 1 (SR)	.28
	240						EF	BRIEF-A init (SR)	Unhealthy	Q 1 (SR)	.20
	240						EF	BRIEF-A inhib (SR)	Healthy	Q 1 (SR)	.20
	240						EF	BRIEF-A inhib (SR)	Unhealthy	Q 1 (SR)	.20
	240						EF	BRIEF-A shift (SR)	Healthy	Q 1 (SR)	.13
	240						EF	BRIEF-A shift (SR)	Unhealthy	Q 1 (SR)	.06
	240						EF	BRIEF-A wm (SR)	Healthy	Q 1 (SR)	.26
	240						EF	BRIEF-A wm (SR)	Unhealthy	Q 1 (SR)	.14
Lowe et al. (2014)	34	67.20	20.24	22.36	NR	>	EF	Go/No-Go (Obj)	Composite	Taste test (Obj)	-.27
	34						EF	SST (Obj)	Composite	Taste test (Obj)	-.05
	34						EF	Stroop (Obj)	Composite	Taste test (Obj)	-.21
Lumley et al. (2016) Study 1	571	66.73	19.80	22.20	NR	NR	Imp	BIS-11 short (SR)	Unhealthy	FFQ (SR)	.15
Macchi et al. (2017)	311	57.56	15.7	NR	NR	NR	EF	IGT (Obj)	Composite	FFQ (SR)	-.04
Marshall et al. (2016)	98	49.00	NR	NR	NR	NR	EF	BRIEF-A global(SR)	Composite	FFQ (SR)	.30
Medic et al. (2016)	43	57.80	30.02	24.56	NR	NR	EF	SST (Obj)	Composite	Meal consump (Obj)	.01
	44						EF	Stroop (Obj)	Composite	Meal consump (Obj)	-.11
	44						Imp	BIS-11 (SR)	Composite	Meal consump (Obj)	.26

Melby et al. (2016)	440	52.00	NR	NR	NR	NR	Imp	BIS Brief (SR)	Unhealthy	Q_2 (SR)	.22
Monds et al. (2016)	1036	63.90	23.08	NR	NR	NR	Cons	IPIP (SR)	Healthy	Questionnaire (SR)	.12
Mottus et al. (2012)	1691	57.72	42.90	NR	NR	NR	Cons	NEO-PI-3 (IR)	Composite	FFQ (SR)	.04
	1691						Cons	NEO-PI-3 (IR)	Healthy	FFQ (SR)	.14
	1691						Cons	NEO-PI-3 (SR)	Composite	FFQ (SR)	.01
	1691						Cons	NEO-PI-3 (SR)	Healthy	FFQ (SR)	.16
Mottus et al. (2013)	1091	49.80	69.60	NR	NR	NR	Cons	NEO-FFI (SR)	Composite	FFQ (SR)	.08
	1091						Cons	NEO-FFI (SR)	Composite	FFQ (SR)	.01
	1091						Cons	NEO-FFI (SR)	Composite	FFQ (SR)	.00
	1091						Cons	NEO-FFI (SR)	Unhealthy	FFQ (SR)	-.01
Myrseth & Fishbach (2009)	67	0	22.64	NR	NR	NR	SC	SC Schedule (SR)	Unhealthy	Taste test (Obj)	-.26
Mullan et al. (2014)	154	74.00	20.30	NR	NR	NR	Imp	BIS-11 (SR)	Healthy	FFQ (SR)	.02
	154						Imp	BIS-11 (SR)	Unhealthy	FFQ (SR)	.18
Nederkoorn et al. (2009) Study 1	57	100	20.00	22	NR	Av	EF	SST (Obj)	Unhealthy	Taste test (Obj)	.28
Olsen et al. (2015)	1006	49.50	42.00	NR	NR	NR	Cons	Questionnaire (SR)	Unhealthy	FF diary (SR)	.21
	1006						Cons	Questionnaire(SR)	Healthy	FF diary(SR)	.09
Pfeiler & Egloff (2018) Study 1	3796	52.50	52.25	NR	NR	NR	Cons	BFI short (SR)	Unhealthy	Q 1 (SR)	.02
Pfeiler & Egloff (2018) Study 2	3422	52.40	48.50	NR	NR	NR	Cons	BFI 10 (SR)	Unhealthy	Q 1 (SR)	.09

Pieper & Laugero (2013) Study 1	29	51.72	4.40	NR	NR	<	EF	CGT (Obj)	Unhealthy	Food Available (Obj)	.32
	29						EF	CBQ short (IR)	Unhealthy	Food Available (Obj)	.11
	29						EF	CBQ short (IR)	Unhealthy	Food Available (Obj)	.11
	29						EF	Flanker (Obj)	Unhealthy	Food Available (Obj)	.12
	29						EF	Dots (Obj)	Unhealthy	Food Available (Obj)	-.30
	29						Imp	CBQ short (IR)	Unhealthy	Food Available (Obj)	.30
Powell et al. (2017)	64	76.56	38.58	25.67	NR	NR	EF	BRIEF-A BRI (SR)	Unhealthy	FF EMA diary (SR)	.12
	64						EF	Go/No-Go (Obj)	Unhealthy	FF EMA diary (SR)	-.01
	64						EF	SST (Obj)	Unhealthy	FF EMA diary (SR)	.08
Price & Higgs (2016) Cue Absent	84	59	27.79	24.02	NR	NR	DoG	DDT (Obj)	Unhealthy	Food Available (Obj)	-.20
Redden & Haws (2013) Study 2	154	NR	NR	NR	NR	NR	SC	BSCS (SR)	Composite	Taste test (Obj)	.07
Redden & Haws (2013) Study 3 No Attention	112	NR	NR	NR	NR	NR	SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.03
	126						SC	BSCS (SR)	Healthy	Taste test (Obj)	-.22
Riggs, Spruijt-Metz et al. (2010)	107	54.00	9.40	NR	NR	NR	EF	BRIEF-A composite (SR)	Healthy	FFQ (SR)	.08
	107						EF	BRIEF-A composite (SR)	Healthy	FFQ (SR)	-.03
	117						EF	BRIEF-A composite (SR)	Unhealthy	FFQ (SR)	-.39
Riggs, Chou et al. (2010)	184	52.00	9.38	NR	NR	NR	EF	BRIEF-A inhib (SR)	Unhealthy	FFQ (SR)	.24
	184						EF	BRIEF-A inhib (SR)	Healthy	FFQ (SR)	.13
	184						EF	BRIEF-A wm (SR)	Unhealthy	FFQ (SR)	.27
	184						EF	BRIEF-A wm (SR)	Healthy	FFQ (SR)	.13

Riggs et al. (2012)	1587	NR	9.30	NR	NR	NR	EF	BRIEF-A composite (SR)	Healthy	FFQ (SR)	.10
	1587						EF	BRIEF-A composite (SR)	Unhealthy	FFQ (SR)	-.17
Robinson et al. (2016)	1056	71.00	21.68	23.34	NR	NR	SC	BSCS (SR)	Unhealthy	FFQ (SR)	-.15
	1056						SC	BSCS (SR)	Unhealthy	Q 1 (SR)	.04
Sabia et al. (2009)	5123	27.90	61.10	NR	NR	NR	EF	Free recall (Obj)	Healthy	Q 1 (SR)	.05
Scholten et al. (2014)	1377	49.20	10.20	NR	NR	NR	Imp	TMCQ (SR)	Unhealthy	FFQ (SR)	.06
Sproesser et al. (2011)	761	100	32.50	23.60	NR	NR	SC	BSCS (SR)	Composite	FFQ (SR)	.28
Stautz et al. (2016)	3099	50.90	13.00	20.38	NR	NR	EF	SST (Obj)	Healthy	24hr recall diary (SR)	.00
	3099						EF	Opp World (Obj)	Healthy	24hr recall diary (SR)	-.02
	3099						EF	Search (Obj)	Healthy	24hr recall diary (SR)	.02
	3099						EF	Ospan (Obj)	Healthy	24hr recall diary (SR)	.11
	3099						Imp	St+Diff (SR)	Healthy	24hr recall diary (SR)	.09
Sutin et al. (2016)	5105	49.60	44.61	NR	NR	NR	Cons	BFI_44 (SR)	Unhealthy	FFQ (SR)	.15
	5105						Cons	BFI_44 (SR)	Healthy	FFQ (SR)	.11
Takahashi et al. (2013)	462	53.54	48.92	NR	NR	NR	Cons	IPIP AB5C (SR)	Composite	FFQ (SR)	.17
Taylor et al. (2010)	119	71.10	23.63	22.38	NR	NR	EF	Go/No-Go (Obj)	Unhealthy	FFQ (SR)	-.01
	119						EF	Go/No-Go (Obj)	Unhealthy	FFQ (SR)	-.47
	119						EF	Go/No-Go (Obj)	Healthy	FFQ (SR)	-.27
	119						EF	N back (Obj)	Unhealthy	FFQ (SR)	.03
	119						EF	N back (Obj)	Unhealthy	FFQ (SR)	.01
	119						EF	N back (Obj)	Healthy	FFQ (SR)	.01

Tomasone et al. (2015)	76	78.95	17.80	NR	NR	NR	SC	BSCS (SR)	Healthy	24hr recall diary (SR)	.24
Vollrath et al. (2012)	327	48.00	8.70	NR	NR	NR	Cons	HPI (IR)	Unhealthy	FFQ (SR)	.02
	327						Cons	HPI (IR)	Unhealthy	FFQ (SR)	.13
	327						Cons	HPI (IR)	Healthy	FFQ (SR)	.17
Wang et al. (2015)	120	100	20.90	20.60	NR	NR	SC	BSCS (SR)	Unhealthy	Taste test (Obj)	.25
Wang (2016)	95	100	21.30	20.70	NR	NR	EF	SST (Obj)	Unhealthy	Taste test (Obj)	.00
	95						Imp	BIS-11 (SR)	Unhealthy	Taste test (Obj)	.14
Whitelock et al. (2017)	113	100	18.90	21.60	NR	Av	EF	Digit span b (Obj)	Healthy	Taste test (Obj)	-.13
	113						EF	Digit span b (Obj)	Unhealthy	Taste test (Obj)	-.16
	114						EF	Corsi (Obj)	Healthy	Taste test (Obj)	-.23
	114						EF	Corsi (Obj)	Unhealthy	Taste test (Obj)	.08
	114						EF	Spatial span (Obj)	Healthy	Taste test (Obj)	-.12
	114						EF	Spatial span (Obj)	Unhealthy	Taste test (Obj)	-.10
Wills et al. (2007)	539	48.00	14.60	NR	NR	NR	SC	(good) questionnaire (SR)	Unhealthy	FFQ (SR)	.08
	539						SC	(good) questionnaire (SR)	Healthy	FFQ (SR)	.21
	539						SC	(poor) questionnaire (SR)	Unhealthy	FFQ (SR)	-.23
	539						SC	(poor) questionnaire (SR)	Healthy	FFQ (SR)	-.03
Wilson et al. (2016)	2031	51.12	50.96	NR	NR	NR	Cons	Chernyshenko Cons (SR)	Healthy	FFQ (SR)	.11
Wong & Mullan (2009)	96	69.00	19.46	NR	NR	NR	EF	Go/No-Go (Obj)	Composite	Q 1 (SR)	.04
	94						EF	ToH (Obj)	Composite	Q 1 (SR)	-.10

Acronyms for Table 5C

NR = not reported

NG = not grouped

Category

Cons = conscientiousness

DoG = delay of gratification

EF = executive functioning

Imp = impulsivity

SC = self-control

Measures

BDS = Behavioral Dyscontrol Scale v2 - motor programming factor (Grigsby & Kaye, 1996)

Bespoke questionnaire – the researchers created their own questionnaire or averaged scores across items from several questionnaires

BFI = conscientiousness facet of the Big Five Inventory (John and Srivastava, 1999), -44 (John, Naumann & Soto, 2008), short (German version; Gertilz & Schupp, 2005), 10 (Rammstedt et al., 2014)

BF-AC = The Big Five Adjective Checklist (Roberts, Bogg, Walton, Chernyshenko, & Stark, 2004)

BIS = Barratt Impulsiveness Scale. -11 = version 2 (Patton, Stanford, & Barratt, 1995), subscales of attentional, motor, and non-planning. Short (Spinella, 2007), Brief (Steinberg, Sharp, Stanford, & Tharp, 2013). Adolescents version (Hartmann, Rief, & Hilbert, 2011).

BRIEF-A = The Behavior Rating Inventory of Executive Function - Adult Version (Roth, Isquith, & Gioia, 2005). BRI = behavioral regulation index. Subscales of inhibit, initiate, shift, wm = working memory. Composite = average score on emotional control, inhibit, working memory, and organization of materials.

BSCS = Brief Self Control Scale 13 items (Tangney, Baumeister, & Boone, 2004).

Card sort = Dimensional Change Card Sort Test in the NIH Toolbox (Gershon et al., 2010).

CEBQ = Children's Eating Behaviour Questionnaire (Wardle, Guthrie, Sanderson, & Rapoport, 2001)

CBQ = Children's Behavior Questionnaire short form (Putnam & Rothbart, 2006). Subscales of impulsivity, inhibition, effortful control.

Chernyshenko Cons = Chernyshenko Conscientiousness Scale (Green et al., 2016)

Children's Gambling Task (Hongwanishkul et al. 2005; Kerr and Zelazo 2004)

Corsi blocks = Corsi block-tapping task, forwards or backwards order (Mihalic et al., 2001).

Counting span task (Conway et al., 2005).

DDC single – single delay discounting choice (e.g., Wulfert, Block, Santa Ana, Rodriguez, & Colsman, 2002)

Delay discounting task (e.g., Epstein et al., 2003; Lagorio & Madden, 2005)

Digit span backwards (e.g., in Wechsler Adult Intelligence Scale, 4th edition; Wechsler, 2008)

Dots task (Davidson, Amso, Anderson, and Diamond 2006)

Flanker test (e.g., Flanker Inhibitory Control and Attention Test in the NIH Toolbox, Gershon et al., 2010)

Fluency Task in the Delis-Kaplan Executive Function System (Delis, Kaplan &, Kramer, 2001)

Free recall = 20 word free recall test in Sabia et al (2009)

GA100 = Goldberg's adjective 100 list (Gerris et al., 1998)

Go/No-Go task (e.g., Hall, Fong, Epp & Elias, 2008; Simmonds, Pekar & Motofsky, 2008)

Go/Stop paradigm (Dougherty, Mathias, Marsh, & Jagar, 2005)

HPI = Hierarchical Personality Inventory for Children, conscientiousness facet (De Fruyt & Mervielde, 1998)

Information sampling task (Clark Roiser, Imeson, Islam, Sonuga-Barke, & Sahakian, 2003)

Inhibitory SCS = Inhibitory self control scale (De Ridder, de Boer, Lugtig, Bakker, & van Hooft, 2011)

Initiatory SCS = Initiatory self-control scale (De Ridder, de Boer, Lugtig, Bakker, & van Hooft, 2011)

Iowa Gambling Task (eg., Bechara, Damasio, Damasio & Anderson, 1994; 1997)

IPIP = conscientiousness facet from the International Personality Item Pool (Goldberg, 1999; Goldberg et al., 2006).

Line walking task (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996)

Mini Marker (Saucier, 1994)

Money Choice Questionnaire (Kirby & Maraković, 1996)

N-back = single adaptive n-back test (Jaggi et al., 2010)

NEO; FFI = Five-Factor Inventory (Costa & McCrae, 1992), PI = personality inventory (MaCrae & Costa, 1987), R = revised (for English language version, Costa & McCrae, 1992), R-3 = revised version 3 (McCrae & Costa, 2010).

Operation span = (e.g., Oberauer et al., 2000; Turner & Engle, 1989)

Opposite Worlds Task in the Test of Everyday Attention for Children (Manly et al., 2001)

Questionnaire good/poor SC = questionnaire assessing good (effortful control) or poor (dysregultion) self control used in Wills et al (2007) and Isasi and Wills (2011).

Raven PM = Raven Standard Progressive Matricies (Raven, 1989, 2000)

Reading + spatial span = aggregate of scores on reading span and spatial span tasks in Alexander (2014, study 1)

SC Schedule = Self-Control Schedule (Rosenbaum, 1980).

SCS = Self-control scale – 36 items (Tangney et al., 2004)

Sky Search Task in the Test of Everyday Attention for Children (Manly et al., 2001)

Spatial wm (working memory) test from the Cambridge Cognition Neuropsychological Test Automated Battery

Spatial span task from the Cambridge Cognition Neuropsychological Test Automated Battery

SRSQ = German Self-Regulatory Skills Questionnaire - self-control subscale (Schmidt & Imhoff, 2011)

Stoop task, (e.g., Delis, Kaplan &, Kramer, 2001; MacLeod, 2005)

Stop-signal Task (e.g., Logan 1994; 1997)

Strengths + Difficulties = Strengths and Difficulties Questionnaire, hyperactivity/impulsivity component Goodman (2001)

SwIFT = Switching, Inhibition and Flexibility Task (FitzGibbon, Cragg, & Carroll, 2014)

Tempe Sorting Task (Marhsall, Wodich & Gorin, 2009)

TIPI = 10 item personality inventory - 2 items for conscientiousness (Gosling, Rentfrow, and Swann, 2003)

TMCQ = Temperament in Middle Childhood Questionnaire (Simonds & Rothbart, 2004)

Tower of London (e.g., Shallice, 1982)

Tower of Hanoi (e.g., Welsh and Huizinga, 2001)

Tower task in the Delis-Kaplan Executive Function System (Delis, Kaplan &, Kramer, 2001)

Tower turns task (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996)

Trail-making task in the Delis-Kaplan Executive Function System (Delis, Kaplan &, Kramer, 2001)

UPPS = UPPS impulsive behavior scale (Whiteside & Lynam, 2001)

Food intake

EMA = exploratory momentary assessment

FF = food frequency; FFQ = food frequency questionnaire

Q 1 = single item

Q 2 F/V = 2 items, one assessing fruit intake and one assessing vegetable intake

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Chapter 1. The Relationship Between Food Consumption, Physical And Mental Health.

People are now living longer, but not necessarily in good health. Large scale multi-national epidemiological studies show that life expectancy has increased in the years from 1950 to 2017, however, the number of years that people live with a disability has, on average, also increased due to the rise in cases of chronic diseases such as obesity, type 2 diabetes mellitus, cancer, and hypertension (GBD 2017 Mortality Collaborators, 2018). This situation has been called a "major public health challenge" by the World Health Organisation (2013, page 7), who recognise the significant impairment that chronic diseases cause to the individual, their family, the national health care system, and the country's social and economic development.

This chapter will provide justification for the study of the predictors of food consumption by outlining the problem of non-communicable diseases for population health with a focus on the UK, exploring evidence for the link between food intake and health outcomes, and showing that guidelines for eating healthily intake in the UK are not adhered to by most of the population. This highlights the opportunity to improve population health through changing current eating behaviour trends.

1.1 Population Health in the UK

The most recent report from the Office for National Statistics (2019a) on the leading causes of death in England and Wales shows that dementia and Alzheimer's disease was the number one cause of mortality, accounting for 12.8% of deaths (for all ages and genders collectively). Dementia and Alzheimer's was the second leading cause of death (11.1%) in Scotland (National Records of Scotland, 2018), and accounted for 12% of deaths in Northern Ireland (Northern Ireland Statistics and Research Agency, 2018). It has been estimated that in 2019 there will be 954,099 people living with dementia, increasing to over 1 million by 2021,

and 2 million by 2051 (Prince et al., 2014). This trend is driven by increasing life expectancy since dementia affects 1.3% of the entire UK population, but 7.1% of those over 65 years old (Prince et al., 2014). As well as being one of the biggest single causes of mortality in the UK, dementia (including Alzheimer's disease) also contributes a significant burden of disability because those with the disease suffer from cognitive impairments, such as difficulty recalling events, concentrating, and planning or carrying out a series of tasks (e.g., cooking a meal), which means that as the disease progresses they require an increasing level of care and supervision (Alzheimer's Society UK, 2019; Lewis, Schaffer, Sussex, O'Neill, & Cockcroft, 2014). The health care costs of dementia and Alzheimer's have been estimated at £4.3 billion, with the costs of paid and unpaid social care equivalent of a further £21.6 billion (Prince et al., 2014).

Obesity also poses a significant threat to public health. Twenty six percent of adults in the UK were classified as clinically obese (i.e., body mass index (BMI) of 30 kg/m^2 or over) in 2016 (National Health Service Digital, 2019). This percentage rose to 29% in 2017 (National Health Service Digital, 2019) and is estimated to rise to 35% by 2030 (The Organisation for Economic Co-operation and Development, 2017). In 2017/18 there were almost 11,000 hospital admissions in the UK with a primary diagnosis of obesity, with an average of 1,323 per 100,000 where obesity was a factor but not the main reason for admission, with rates as high as 3,000 per 100,000 in some areas of the country (National Health Service Digital, 2019). Excess body weight is an issue because it can lead to impaired daily living (e.g., reduced mobility) and is related to other physical health complications such as type 2 diabetes, ischemic heart disease, some types of cancer (including breast and bowel cancer), stroke, high blood pressure, gallstones, reduced fertility, osteoarthritis, liver and kidney disease, asthma, Alzheimer's disease, sleep apnoea, lower back pain, and gout (Department of Health, 2011; GBD 2017 Risk Factor Collaborators, 2018; Malnick &

Knobler, 2006). There is also evidence of a link between obesity and poor mental health, for example, depression (Luppino et al., 2010). Furthermore, in a cohort study of 3.6 million adults in the UK, 5.5% of deaths were attributed to overweight (i.e., BMI $\geq$ 25 kg/m^2) and obesity (Bhaskaran, dos-Santos-Silva, Leon, Douglas, & Smeeth, 2018). Taken together this evidence shows that excess body weight poses a significant health and health-care burden in the UK.

The prevalence of diabetes in the UK has increased to 3.8 million diagnosed cases, with an estimated further 1 million cases of type 2 diabetes undiagnosed (Diabetes UK, 2018). This number is expected to rise to over 5.6 million cases in 2035/2036 (Hex, Bartlett, Wright, Taylor, & Varley, 2012). Five hundred people in the UK die prematurely every week from diabetes (National Health Service Digital, 2017) and even more live with the preventable consequences, for example, blindness (due to diabetic retinopathy) and lower limb amputation (Mathur et al., 2017; Holman, Young, & Jeffcoate, 2012). The direct costs to the National Health Service from type 2 diabetes (e.g., screening and prescriptions) were estimated as £8.8 billion in the year 2010/2011, with £13 billion spent on indirect costs, such as, loss of productivity, heart failure, foot ulcers, and depression (Hex et al., 2012). Given the rise in the incidence of diabetes this amount is likely to be higher now in 2019.

In 2015 there were 2.5 million people living with cancer in the UK, the diagnosis rate appears to be increasing and it is estimated that prevalence will rise to 4 million by 2030 (Macmillan Cancer Support, 2019; Office for National Statistics, 2019b). Cancer contributes significantly to mortality, with 450 deaths every day in 2014/16 attributable to cancer (Cancer Research UK, 2019), although the Office for National Statistics (2019b) reports that mortality rates dropped from 2008 to 2017; individuals may now live longer after a diagnosis of cancer, which also means that morbidity rates and the medical costs per case may have increased if the patient does not go into remission. The annual cost of cancer services to the National

Health Service was estimated at £5 billion in 2010/2015, with costs of £18.3 billion to society, for example, due to lost productivity (Department of Health and Social Care, 2015).

Cardiovascular disease is another non-communicable disease that is prevalent in the UK. In recent years, there has been a reduction in mortality and morbidity from cardiac events (e.g., cardiovascular disease, chronic heart disease, and stroke), which is partially attributable to improved medical care (Bhatnagar, Wickramasinghe, Wilkins, & Townsend, 2016; British Heart Foundation, 2019). For example, there are now more people being treated or medicated for hypertension and there was a 20% reduction in the number of cases of (total) raised cholesterol between 1998 and 2017 (National Health Service Digital, 2018). However, despite downwards trends, cardiovascular disease still poses a substantial burden in the UK; 14% of adults who responded to the 2017 Health Survey for England (National Health Service Digital, 2018) reported having a diagnosis of cardiovascular disease and treatment costs in the UK were an estimated at £12 billion in 2017, with 46% of costs directly from medical care (European Heart Network, 2017).

Interventions are needed to reduce the burden of non-communicable diseases in the UK. Changing lifestyle behaviours, in particular diet, presents the opportunity to reduce the burden of chronic disease since poor diet is responsible for 11 million deaths and 255 million disability adjusted life years (an indicator of morbidity) per annum globally (GBD 2017 Diet Collaborators, 2019). Moreover, in projections of the years life lost (globally) in 2040, dietary risk factors were 7 of the top 25 leading risk factors that accounted for the difference between best and worst case scenarios forecasted (Foreman et al., 2018).

1.2 Food Consumption And Health Outcomes

This section reviews evidence for the link between the consumption of certain types of food and the increase or decrease in the risk of negative health outcomes, with a focus on the health conditions discussed in Section 1.1. This list is not exhanustive; the food types

chosen for this brief review are those identified in the Global Burden of Diseases, Injuries, and Risk Factors Study as having "convincing or probable evidence of causation"[1] based on the strength and quality of the evidence (GBD 2017 Risk Factor Collaborators, 2018; page 1). The GBD study collated data from almost 47,000 sources on adults aged over 25 in 195 countries from the years 1990 to 2016 and can therefore be considered a comprehensive resource. Foods are presented in order of the attributable disability adjusted life years, since this provides an estimate of the healthy years of life lost due to disease, disability, and premature death, and is an indicator of the burden of disease caused by dietary risk factors (see Table 1).

Table 1

Disability adjusted life years (DALYs) and all cause mortality attributable to dietary risk factors with convincing or probable evidence of causation, adapted from the Global Burden of Disease Study 2017

	DALYs 2017 (thousands)	Mortality 2017 (thousands)
Whole grains	82500	3070
Sodium	70400	3200
Fruit	64800	2420
Nuts and seeds	49900	2060
Seafood omega 3	32400	1440
Fibre	19000	873
Legumes	11000	535
Sugar sweetened beverages	4450	137
Processed meat	3570	130
Vegetables	3420	1460
Red meat	1310	25

[1] See the World Cancer research Fund/ American Institute for Cancer Research (2018) report into "Food, nutrition, physical activity, and the prevention of cancer: a global perspective" for a detailed description of the level of evidence appraised.

1.2.1 Whole grains. The GBD study found that 3 million deaths and 82 million disability adjusted life years, were attributable to low intake (less than the recommended 100-150g per day) of whole grains (e.g., oats, barley and brown rice, or whole grain products such as whole wheat bread or pasta, in which the natural proportions of bran, germ, and endosperm are retained), making low intake of whole grains the leading dietary risk factor for disability adjusted life years in both males and females (GBD 2017 Diet Collaborators, 2019). Moreover, insufficient intake of whole grains was ranked in the top 10 risk factors that accounted for the difference in the best and worst health scenarios in projections of life years lost in 2040 (Foreman et al., 2018). Findings from a meta-analysis of 9 randomised-control trials suggest that the consumption of whole grains is associated with a reduction in systemic inflammation, high levels of which are thought to play a role is cardiovascular diseases, certain types of cancer, type 2 diabetes, and obesity (Xu et al., 2018). Furthermore, evidence from epidemiological and intervention studies indicates that consuming whole rather than refined grains could help to reduce the risk of type 2 diabetes, cardiovascular disease, and some types of cancer (Seal & Brownlee, 2015).

1.2.2 Salt. High sodium intake (above 1-5g per day measured by 24 hour urinary sodium) was shown to account for 3 million deaths and 70 million disability adjusted life years in 2017, and there is evidence that it causes stomach cancer, cardiomyopathy, and chronic kidney disease (GBD 2017 Diet Collaborators, 2019; Wong et al., 2017). Evidence from several meta-analyses of randomised-controlled trials and prospective studies suggests that reducing sodium/salt intake can reduce blood pressure, risk of stroke, and ischemic heart disease in adults (Aburto et al., 2013; He, Li, & MacGregor, 2013). However, it should be noted that very low sodium in the diet is also associated with increase the risk of mortality, and therefore moderate intake is recommended (Graudal, Jürgens, Baslund, & Alderman, 2014).

1.2.3 Fruits and vegetables. Although the health outcomes attributable to the consumption of fruits and of vegetables are presented separately within reports on the GBD study (e.g., GBD 2017 Diet Collaborators, 2018), they will be discussed in the same section of this thesis as individual studies have often assessed the combined intake of fruit and vegetables (F&V). A wealth of evidence, summarised in this section, suggests that eating a diet that is high in F&V can reduce the risk of chronic diseases and thus reduce the associated burden of disability, morbidity, and mortality. For example, The GBD study found that low intake of fruits (below the recommended 200-300g per day) accounted for 2 million deaths and 65 million disability adjusted life years in 2017, while low intake of vegetables (below the recommended 290-430g per day) accounted for a smaller but still substantial 1 million deaths and 3.4 million disability adjusted life years in 2017, which increased from figures in 2007 (GBD 2017 Diet Collaborators, 2019). The authors indicated that there was evidence that low F&V consumption caused morbidity and mortality from chronic heart disease, ischaemic stroke, intercerebral and subarachnoid haemorrhage, and in the case of fruit, certain types of cancer and type 2 diabetes. Conversely, high intake of F&V has a health-protective effect. An epidemiological study in which 65,226 participants, aged 35 years and over, living in England, were followed for an average of 7.7 years, showed that high consumption of F&V (7 or more portions per day) was associated with a reduction in all-cause mortality (Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014). Several meta-analyses provide evidence that individuals who consume a high amount of F&V are at a reduced risk of developing cardiovascular diseases (e.g., Borgi et al., 2016; Crowe et al., 2011; Dauchet, Amouyel, Hercberg, & Dallongeville, 2006; Zhang et al., 2015), and certain kinds of cancer (e.g., cancer of the digestive system, pancreas and bladder; Lui et al., 2015; Maisonneauv & Lowenfels, 2015; Vainio & Weiderpass, 2006; Wu et al., 2016). Increasing the consumption of F&V may also be effective for reducing obesity since it appears to be related to increased

satiation and better management of long term weight loss (if the dietary intervention also advises reduced energy intake overall; Rolls, Ello-Martin, & Tohill, 2004).

There is evidence of cognitive and mental health benefits associated with the consumption of sufficient F&V. A systematic review of cohort studies concluded that increased intake of F&V reduced the risk of dementia and speed of cognitive decline in old age (Loef & Walach, 2012). In addition, evidence from observational studies suggests that individuals report higher wellbeing on the days that they consume higher levels of F&V than on the days that they consume lower levels (Conner, Brookie, Carr, Mainvil, & Vissers, 2015) and those who typically consume more F&V experience higher wellbeing than those who consume lower levels (Blanchflower, Oswald, & Stewart-Brown, 2013). High intake of fruit or vegetables was also found to be associated with a reduction in risk of depression in a meta-analysis of 18 epidemiological studies (Saghafian et al., 2018).

1.2.4 Seafood sources of omega-3 fatty acids. The low consumption of seafood sources of omega-3 fatty acids, such as salmon, sardines, and mackerel (below the recommended 200−300 mg per day) was linked to 1.4 million deaths globally and 34 million disability adjusted life years in 2017 (GBD 2017 Risk Factor Collaborators, 2018). Meta-analytic reviews of prospective cohort studies suggest that intake of omega-3 fatty acids from seafood is associated with a lower risk of ischemic heart disease, myocardial infarction, stroke, Alzheimer's disease, certain types of cancer, and depression (Jayedi, Zargar, & Shab-Bidar, 2019; Song, Su, Wang, Zhou, & Guo, 2011; Wu et al., 2015; Yang, Kim, & Je, 2018; Yu, Zou, & Dong, 2014; Zaho et al., 2019). Moreover, a meta-analysis of 14 intervention studies suggested that consuming oily fish led to a reduction in cardiovascular risk factors (Alhassan, Young, Lean, & Lara, 2017).

1.2.5 Nuts and seeds. Low intake of nuts and seeds (below 16−25 g per day) was shown to account for 2 million deaths and 50 million disability adjusted life years in 2017,

with evidence of causation for ischaemic heart disease and type 2 diabetes (GBD 2017 Diet Collaborators, 2019). Further evidence suggests that higher consumptions of nuts is associated with a reduction in the risk of mortality from certain types of cancer, respiratory disease, diabetes, and infections (Aune et al., 2016; Grosso et al., 2015). A systematic review of 49 studies concluded that the consumption of nuts (e.g., almonds, walnuts, and peanuts) was beneficial in the prevention and treatment of some chronic diseases related to glycemic metabolism, oxidative stress, and inflammation (de Souza, Schincaglia, Pimentel, & Mota, 2017). Less research relating to the consumption of seeds and health outcomes has been conducted and quantitatively synthesised.

1.2.6 Fibre. Fibre can be found in varying amounts in foods such as fruit, vegetables, potatoes with their skin on, legumes, and whole grains (Scientific Advisory Committee on Nutrition, 2015). The low consumption of fibre (below 19-28g per day) was linked to 873 thousand deaths globally and 19 million disability adjusted life years in 2017 (GBD 2017 Risk Factor Collaborators, 2018). Evidence from a review of primarily epidemiological studies suggests that consuming fibre can reduce the risk of cardiovascular disease, type 2 diabetes, obesity, and gastrointestinal disorders (Anderson et al., 2009). Furthermore, increased fibre intake can have disease reversal effects, such as lowering blood pressure, improving blood glucose control (important for diabetics), assisting with weight loss, and improving the digestive transit of food (Anderson et al., 2009). A more recent meta-analysis of 912 papers with almost 3 million participants found that increasing intake of fibre reduced the risk of bowel cancer (Gianfredi et al., 2019).

1.2.7 Legumes. The consumption of legumes such as peas, lentils, and beans, has been linked to good cardiovascular health, improved metabolic control in type 2 diabetics, and weight control (Çakir, Uçarli, Tarhan, Pekmez, & Turgut-Kara, 2019; Polak, Phillips, & Campbell, 2015). The global burden of diseasestudy found that 535 thousand deaths and 11

million disability adjusted life years in 2017 were attributable to low intake of legumes (less than 50−70 g per day; GBD 2017 Diet Collaborators, 2019). Despite the health consequences of low consumption of legumes, there has not been much research in this area.

1.2.8 Sugar. Sugar sweetened beverages (e.g., including carbonated beverages, sodas, energy drinks, and fruit drinks, but excluding 100% fruit juice or vegetable juice) in particular have been found to have a negative impact on mortality and morbidity; 137 thousand deaths globally and almost 4.5 million disability adjusted life years in 2017 were attributed to high consumption of sugar sweetened beverages (GBD 2017 Risk Factor Collaborators, 2018). The same study found evidence for a causal relationship between the consumption of sugar sweetened beverages and ischemic heart disease and type 2 diabetes, through impact on BMI status (GBD 2017 Risk Factor Collaborators, 2018). Khan and Sievenpieper (2016) reviewed evidence from prospective cohort studies and found a significant association between the consumption of sugar sweetened beverages (including F&V juices) and weight gain, obesity, diabetes, metabolic syndrome, hypertension, and ischemic heart disease. However, the authors noted mixed findings of an association between 100% fruit juice and poor health outcomes such as diabeties and cardiometablic diseases (Khan & Sievenpieper, 2016).

In terms of sugar levels in foods, the World Health Organisation (2015) provide evidence that increased consumption of free sugars (i.e., monosaccharides (such as glucose, fructose) and disaccharides (such as sucrose or table sugar) that are added to foods by the manufacturer, cook or consumer, and includes sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates) is associated with an increase in body weight, while a decrease in sugars consumption is associated with reduced body weight. The World Health Organisation (2015) suggested that the consumption of foods high in sugar can displace more nutritious food items, which reduces diet quality and increases energy density, for example,

choosing to eat sweets/candy as a snack rather than carrot sticks and hummus (i.e., vegetables and legumes). Indeed there is an association between the intake of free sugar and weight gain; with Jebb (2015) interpreting this evidence to suggest that reducing sugar consumption could reduce the prevalence of obesity. Restricting the intake of free sugars, in terms of the overall quantity or frequency of consumption can benefit oral health by reducing dental cariers (i.e., tooth decay; Moynihan, 2016; van Loveren, 2018; World Health Organisation, 2015).

1.2.9 Processed and red meat. The GBD Risk Factor Collaborators (2018) separated data regarding the consumption of processed meat (i.e., meat preserved by smoking, curing, salting, or the addition of chemical preservatives; such as sausages and bacon) from the consumption of red meat (e.g., beef, pork, lamb, and goat, but excluding processed meat). They reported that 130 thousand deaths and 3.6 million disability adjusted life years were attributable to high intakes of processed meat (above the recommended consumption level of 0-4g per day), while 25 thousand deaths and 1.3 million disability adjusted life years were attributable to high consumption of red meat (above the recommended maximum of 18–27g per day; GBD 2017 Risk Factor Collaborators, 2018). Furthermore, there was evidence that both kinds of meat cause colon and rectum cancer, as well as type 2 diabetes, with processed meat additionally causing ischaemic heart disease (GBD 2017 Risk Factor Collaborators, 2018). One prospective study of over 80,000 participants showed that an increase in red meat consumption of over half a (85g) serving per day for 4 years was associated with higher all cause mortality in the following 4 years, but a reduction in red meat consumption coupled with increased consumption of other sources of protein (e.g., eggs, fish, whole grains, and nuts) was associated with a lower risk of death (Zheng et al., 2019). The study by Zheng et al. (2019) also found that the association between increased meat consumption and mortality was stronger for processed (e.g., a hamburger) than unprocessed red meat (e.g., a beef steak). However, a meta-analysis of 9 prospective studies found that high consumption of processed

red meat, but *not* unprocessed red meat was linked to higher all-cause mortality (Larsson & Orsini, 2014). The conflicting findings surrounding the association between unprocessed red meat and mortality/morbidity warrent further investigation as the results have implications for dietary guidelines and public health.

1.2.10 The Western diet. Although not specifically addressed within the GBD study, eating a diet that is high in saturated fat (found in butter, ghee, suet, lard, coconut oil, palm oil, and fatty cuts of meat) and trans-fat (i.e., partially or fully hydrogenated fat/oil), sugar, sodium (salt), and ultra-processed foods (i.e., foods that have undergone multiple physical, biological, and/or chemical processes) for a prolonged period of time can increase the risk of health problems (Fiolet et al., 2018; National Health Service, 2017; Srour et al., 2019; World Health Organisation, 2015). This 'Western diet' been linked to increased risk of obesity, cardiovascular disease, certain types of cancer, metabolic syndrome, and autoimmune disorders (Carrera-Bastos, Fontes-Villalba, O'Keefe, & Lindeberg, 2011; WHO, 2015; Zhang et al., 2015). Francis and Stevenson (2013) cite evidence to suggest that a Western diet may also contribute to the development of neurodegenerative diseases (e.g., Alzheimer's disease). In addition, a large-scale prospective study found that 4 servings of ultra-processed foods per day was associated with a relative increase in all cause mortality of 62%, with additional servings increasing the risk by 18% (Rico-Campà et al., 2019). Longitudinal research (median 6.2 years) has also found that the consumption of processed fast-foods (e.g., hamburgers, sausages and pizza) has a dose-reponse relationship to clinical depression, with higher levels of depression reported at higher levels of consumption (Sánchez-Villegas, Toledo, de Irala, Ruiz-Canela, Pla-Vidal, & Martínez-González, 2012). Furthermore, snack products such as crisps, chocolate, ice-cream, cakes, and biscuits that are often highly processed and contain a high amount of saturated fat, sugar, and/or salt, are a stereotypical feature in the Western diet (Public Health England, 2016).

1.2.11 Defining healthy and unhealthy eating. For the purpose of this thesis, healthy foods are those associated with health benefits and reduced risk of ill health as discussed above, e.g., fruit, vegetables, whole grains, legumes, seafood that contains omega-3, nuts and seeds, and high fibre foods. Eating such foods is referred to as *healthy eating* (a health promoting behaviour). Unhealthy foods are those associated with the development and increased risk of ill health, e.g., food with high amounts of saturated fat, sugar, or sodium per serving, as well as red and processed meat, and sugar sweetened beverages. Eating such foods is referred to as *unhealthy eating* (a health risk behaviour). Overall, a health promoting diet involves eating plenty of healthy food and limiting or avoiding unhealthy foods. In order to improve clarity in reporting the outcome measure (quantity and type of foods cosumed) in Chapter 5, the meta-analysis, the term h*ealthful eating* is the term used to describe a dietary pattern with a high proportion of foods that are conductive to health and(/or) a low proportion of foods that are not conductive to health.

1.3 Food Intake in the UK

Poor diet is a major contributor to the growing burden of chronic disease in the UK and it has been estimated that the associated health problems (outlined in Section 1.1) cost the NHS around £6 billion per annum (Rayner & Scarbough, 2005; Scarborough et al., 2011). The World Health Organisation (2013) recognises that alcohol, smoking, physical inactivity, and poor diet are modifiable behavioural risk factors for major chronic diseases and mortality. In the UK, diet contributes more to the burden of disease than the other three factors combined, which highlights the importance of investigating and changing dietary patterns (Scarborough et al., 2011).

1.3.1 UK healthy eating guidelines. Given the evidence of a clear relationship between diet and health, the Eatwell Guide (which includes the Eatwell Plate) was developed; led by Public Health England in association with the Welsh Government, Food Standards

Scotland, and the Food Standards Agency in Northern Ireland (Public Health England, 2016). It is recommend in the Eatwell Guide that individuals over the age of 11 years eat 5 (80g) portions of F&V per day ('5-a-day'); these can be eaten in a variety of forms (e.g., fresh, frozen, tinned (in juice not syrup) or dried) and can be eaten on their own or mixed in dishes such as pasta sauce, soup, or desserts. F&V in pre-packaged convenience foods also contribute towards total daily intake. Individuals do not need to eat a full portion of a single fruit/vegetable for it to count towards their daily total. For example, half a portion of broccoli and half a portion of peas would count as one whole portion of vegetables. One (140g) to 2 portions of oily fish per week is also recommended in the Eatwell Guide (Public Health England, 2016). Drawing on the Scientific Advisory Committee on Nutrition (2015) report into carbohydrates and health, it is recommended that adults and adolescents over the age of 15 consume 30g of fibre per day (Public Health England, 2016).

There are no official guidelines in the UK for the amount of whole grains that should be consumed per day; however, the Eatwell Guide advises that one third of a main meal (i.e., breakfast, lunch, and dinner) be made up of starchy carbohydrates (e.g., bread, rice, or pasta) and to choose whole grain over refined versions (Public Health England, 2016). There is also no recommendation for how many nuts/seeds or legumes (e.g., lentils and beans) to consume; these are included in the 'protein' category of the Eatwell Plate (Public Health England, 2016). The Eatwell Guide specifies that plain (i.e., unsalted nuts should be chosen) and that legumes (80g+) can count as a maximum of 1 portion of vegetables and contribute towards the 5-a-day target (Public Health England, 2016).

There are recommendations in the Eatwell Guide for the upper limit of fat, sugar, and sodium that should be consumed in a single day. It is recommended that saturated fat intake does not exceed 10% of dietary energy intake (equivalent to less than 30g per day for adult males and less than 20g for adult females), sugar does not exceed more than 5%

(approximately 30g or 7 cubes) of daily calorie intake and salt does not exceed 6g for both males and females (Public Health England, 2016; Scientific Advisory Committee on Nutrition, 2019). It is also recommended in the Eatwell Guide that red meat (e.g., beef or lamb) and processed meat (e.g., sausages, bacon, and cured meats) are limited to no more than 70g per day in total (PHE, 2016). Furthermore, the Eatwell Guide advises people to avoid or limit foods that contains a high amount of fat, sugar and/or salt and a low amount of micronutrients (e.g., chocolate, sweets, biscuits, pastries, cakes and crisps) and that individuals make up no more than 20% of their daily calorie intake from snacks (i.e., all foods consumed between the three main meals; Public Health England, 2016). These guidelines are for healthy individuals and may differ for those who have a chronic disease identified in section 1.1, such as diabetes or hypertension.

1.3.2 Adherence to dietary guidelines in the UK. In the UK, consumption of healthy foods falls below the recommended levels. Data collected between 2008 and 2011, from over 3,000 adults in the UK showed that consumption of whole grain products was low, however, the amount of whole grains eaten increased slightly if products which included < 10% whole grains were considered (Mann, Pearce, McKevith, Thielecke, & Seal, 2015). Moreover, 18% of adults surveyed ate no whole grain foods during the data collection period (Mann et al., 2015), which suggests that they will be at increased risk of developing the health complications discussed in section 1.2.1 (e.g., systemic inflammation). Robinson and Chambers (2018) note that the absence of guidelines quantifying how many portions of whole grain products to consume per day makes it challenging to increase consumption levels and improve health outcomes. The UK National Diet and Nutrition Survey found that in 2014/5 and 2015/16 only 31% percent of the adults (aged 19 – 64) surveyed achieved the guidelines to eat 5 portions of F&V per day, with an average intake of 4 portions per day (Roberts, et al., 2018). The average portions consumed per day remained stable across the 8

years of the study, but the percentage of participants achieving "5-a-day" was shown to increase slightly from 2010/14 to 2015/16. The same survey found that only 9% of adults surveyed met the recommended daily amount of fibre (30g), and the average intake was 19g; intake was higher for males (20.7g than females 17.4g, with 13% and 4%, respectively, meeting the guidelines). The consumption of oily fish (specifically those that contain omega-3) was low at 8g per day for adults, the intake almost doubled for 65-74 year olds, however, it was still below the recommendations in the Eatwell Guide of 140-280g per week (Roberts et al., 2018). The same study also found that, at the latest data collection time point, only 9% of adults ate the recommended amount of fibre, however, this was an increase from the previous two data collection time points (Roberts et al., 2018).

The national surveys discussed above did not assess the intake of nuts/seeds or legumes. Data from a heterogenous sub-sample of 1315 participants from the The European Prospective Investigation into Cancer and Nutrition showed that those from the UK ate on average 5.43g of nuts and 1.07g of seeds per day over the 24-hour food recall period. More recent data from the UK Biobank study showed that participants ate an average of 5.5g of nuts per day if they also ate red meat more than 3 times per week (n = 51,144), whereas vegans (who ate no meat or animal products such as eggs or dairy; n = 102) ate 14.5g of nuts per day (Bradbury, Tong & Key, 2017). Furthermore, meat eaters ate 15g of legumes/pluses per day, while vegetarians (n = 1243) ate 33g and vegans ate 52.1g (Bradbury et al., 2017). This data indicates that the consumption of nuts and legumes may vary relative to other protein sources in the diet, however the sample all identified as white ethnicity and were between the ages of 40-69 years old, which means that the data is not representative of the population as a whole. In order to collect more representative data, existing studies of food intake in the UK could include questions on the intake of nuts/seeds and legumes as these foods have been linked to positive health outcomes (described in section 1.2).In contrast to

the under-consumption of health enhancing foods, the most up-to-date statistics for sodium intake from data collected in 2014 suggest that intake is above recommendations at 8g per day (Bates et al., 2016). The consumption of free sugars was found in the UK National Diet and Nutrition Survey to be consistently higher than recommended, making up on average 11.1% of daily energy intake, with 87% of adults exceeding the guideline amount of 5% of daily energy intake (Roberts et al., 2018). Sugar-sweetened beverages accounted for 22% of free sugar intake in 11-18 year olds and 16% in 19-64 year olds (Roberts et al., 2018). The consumption of red and processed meat has remained stable since 2008/2009, but was on average 194g per day for adults in 2015/16, which is over double the amount recommended (Public Health England, 2018; Roberts et al., 2018). Furthermore, although the average intake of fat as a percentage of energy from dietary intake has decreased from 1986/7 to 2016/7, it settled above the recommended level (of 10% of energy intake) during 2008/9 to 2015/6; average intake ranged from 11.9 to 14.3% across age groups (from 4 to 75+ years; Roberts et al., 2018).

Changes to bring food consumption in line with the recommendations in the Eatwell Guide are expected to have a large effect on population health and the total cost of health care in the UK. For example, a prospective study by Khaw et al. (2008) with over 20,000 adults in the UK established lower mortality in a group of individuals who ate over 5 portions of F&V per day compared to those who ate less than this recommended amount. In addition, reducing sugar levels to the recommended limit could prevent over 4,000 early deaths and 200,000 instances of tooth decay, as well as saving the National Health Service an estimated £480 million per annum on the costs associated with obesity and diabetes (Tedstone, Targett, Allen, & the staff at Public Health England, 2015).

Specific population groups have also shown poor dietary patterns. In a study of the food consumption patterns of British undergraduate students, Tanton, Dodd, Woodfield, and

Mabhala (2015) found that only 19% of 345 participants surveyed had a healthful eating pattern; i.e., high F&V consumption (which met the UK guidelines) and low intake of 'unhealthy snacks' or convenience food. The majority of participants (50%) had a low F&V (an average of 2-3 portions per day) and a moderate intake of unhealthy snacks and convenience food. However, 19% showed a risky pattern of low F&V coupled with a high intake of unhealthy snacks (2+ times per day) and convenience or fast food (an average of 11 times per week). This is an issue because students with an unhealthful diet are at increased risk of developing one or more of the health conditions discussed in section 1.1 (e.g., obesity or cancer), which may impact upon academic performance, daily functioning, and wellbeing. Furthermore, poor diet can impact the mental health of students and add to the increasing demand on university student counselling services (Broglia, Millings, & Barkham, 2017). For example, in a study of 3,706 students at 7 universities in the UK, El Ansari, Adetunji & Oskrochi (2014) found that eating F&V was negatively associated with stress and depressive symptoms, while eating snack foods high in refined sugar and fast food was associated with higher depressive symptoms. Patterns of unhealthy eating in young adulthood may form into long-term habits and negatively impact health across the lifespan (Friedman et al., 2008; Wiium, Breivik, & Wold, 2015).

1.4 Conclusion

This chapter has described evidence suggesting that eating foods such as fruit, vegetables, whole grains, legumes, nuts/seeds, oily fish, and sufficient fibre has significant physical and mental health benefits. Intake of these foods in the UK does not meet the recommended level. In contrast, the overconsumption of foods that are high in fat, sugar, and sodium (such as fast food, sugar sweetened beverages, and processed meat), has been linked to the development of chronic diseases and weight gain leading to obesity, and these foods are overconsumed in the UK. The burden of chronic diet-related diseases in the UK is

currently high, and interventions are therefore needed in order to improve diet quality and to reduce mortality and morbidity. This thesis will focus on understanding the key determinants of healthy and unhealthy eating behaviour in the UK as targets for change within future health promotion interventions. The next chapter will examine the use of psychological theories to describe, explain, and predict eating behaviour.

Chapter 2. The Use of Theoretical Models to Predict and Explain Health Behaviour

This chapter will give a background into the use of theoretical models to describe and predict health behaviour and discuss the limitations of these models, which includes using cognitive constructs (specifically intention) as a predictor of behaviour, and failing to adequately account for the influence of temporal factors, impulsive processes, and the environment on behaviour. It will then introduce Temporal Self-regulation Theory (TST; Hall & Fong, 2007) and explore evidence for the key hypotheses drawn from the model.

2.1 Theoretical Models of Health Behaviour

In order to understand health behaviours, researchers have formulated and tested theoretical models that aim to, i) give an account of the proposed relationship between antecedents and behaviour, ii) statistically estimate the extent to which antecedents account for behaviour, and iii) explain the extent to which changes in the antecedents account for changes in the behaviours of interest. In other words, these models provide a structured account of the relationship between antecedents and behaviour, which can be tested in order to establish the factors that best predict the likelihood of a given behaviour being enacted, and explain the mechanisms for behaviour change (Aboud & Singla, 2012). The most successful models can then be used to inform the development of interventions to promote health enhancing behaviours (e.g., consumption of F&V) and decrease health risk behaviour (e.g., high salt intake); guidelines from the Medical Research Council advise that intervention developers use the best available evidence and suitable theory when designing and evaluating health behaviour change interventions (Craig et al., 2013).

Theoretical frameworks of health behaviour often view the individual as a rational decision maker, who systematically and deliberatively processes information, and behaves based on their perceptions of the situation and environment (as opposed to the objective

reality). For example, the subjective expected utility model (Savage, 1954) suggests that individuals appraise potential outcomes of a decision before taking action. This has been echoed in the health belief model (Becker, 1974; Janz & Becker, 1984), which proposes that individuals weigh up the perceived susceptibility and severity of potential health problems, as well as the benefits and barriers to acting. In the same way, protection motivation theory (Maddux & Rogers, 1983) considers that an individual's appraisals of threat and coping strategies will determine their 'protection motivation', which in turn predicts behaviour. This protection motivation is similar to the construct of intentions within the theory of reasoned action (Fishbein 1967), which was revised into the theory of planned behaviour (Ajzen & Madden, 1986) and proposes that intentions are predicted by attitudes (i.e., beliefs or evaluations of the behaviour), subjective norms (i.e., beliefs about the expectations of significant others), and perceived behavioural control. The idea of intentions is included as 'goals' within social cognitive theory (Bandura, 1982), which are suggested to be influenced by an individual's belief in their own capability (i.e., self-efficacy) and expectations about the outcomes of action. Social cognitive theory proposes that goals directly influence behaviour (Bandura, 1982). Exploring and evaluating these theories in more detail is beyond the scope of this thesis; a full review of the main social cognitive models of health behaviour can be found in Conner and Norman (2015).

Evidence, taken from multiple meta-analyses of prospective studies, suggests that social cognitive predictors (e.g., attitudes and outcome expectancies) account for up to 60% of variance in intentions when data is aggregated across individuals and then analysed (Conner & Norman, 2015). Intention (i.e., the extent to which an individual is willing to carry out a behaviour) consistently accounts for, on average, one-third of variance in health behaviours, including eating behaviours (Guillaumie, Godin, & Vezina-Im., 2010; McEachan, Lawton, & Conner, 2011; Sleddens et al., 2015). This means that a substantial

proportion of the variance in behaviour is left unexplained. This discordance between intention and behaviour (the 'intention-behaviour gap') may be due to the presence of inclined abstainers. Many individuals do not act despite reporting positive intentions to do so; inclined abstainers have been found to make up almost half of the sample in some research studies (Orbell & Sheeran, 1998; Rhodes & de Bruijn, 2013; Sheeran, 2002). The presence of the intention–behaviour gap suggests that the construct of intention may be insufficient to explain behaviour (Webb & Sheeran, 2006). This is a theoretical problem for models based on the construct of intention (including the theory of planned behaviour, but also protection motivation theory, and goals within social cognitive theory), which do not adequately explain instances of seemingly irrational behaviour when individuals fail to act on their intentions or act counter to their intentions. Furthermore, research often focuses on only a single intention or goal (e.g., to avoid unhealthy snacks) and does not account for other competing goals (e.g., eat delicious foods), which may produce behaviour that is inconsistent with the measured intention (i.e., eating unhealthy snacks that taste delicious).

Furthermore, intention alone does not appear to be sufficient to promote changes in behaviour. Experimental studies show that medium–to-large changes in intentions (i.e., d_+ = 0.66; Webb & Sheeran, 2006) lead to only small-to-medium (i.e., d_+ = 0.36; Webb & Sheeran, 2006) changes in behaviour (Armitage & Conner, 2001; Guillaumie, Godin, Manderscheid, Spitz, & Muller, 2012; McEachan et al., 2011). To try and address this problem, researchers have included additional constructs in studies using intention to model health behaviour. For example, past behaviour (e.g., Åstrøsm, 2004; Wong & Mullan, 2009), habit (i.e., the extent to which a behaviour is automatically triggered by cues in the environment and has become associated with those cues; de Bruijn, Kroeze, Oenema, & Brug, 2008; Kothe, Sainsbury, Smith, & Mullan, 2015; Verhoeven, Adriaanse, Evers & de Ridder, 2012) executive or cognitive functions that enable the top-down control of behaviour

(e.g., Allan, Johnston, & Campbell, 2011; Wong & Mullan, 2009), and different styles of planning (e.g., action and coping planning; Evans, Kawabata, & Thomas, 2015; van Osch et al., 2010) have been tested as additional constructs to explain why intention is not always translated into behaviour. Research studies such as those cited above typically find that including additional constructs can explain more variance in behaviour. However, research streams exploring additional factors within social cognitive models, have, for the most part, developed separately and often have not included an overarching theoretical framework to explain the interplay between these additional factors (Conner & Norman, 2015).

Self-regulatory, dual-process models of health behaviour (e.g., Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004) have gained in popularity in recent years and can specifically account for instances in which individuals fail to act in a rational or intentional manner. These models propose two separate but interacting systems; (i) one is responsible for reflective, deliberated, and rational responses in line with intentions and long-term goals, and (ii) a separate system produces impulsive, automatic responses to cues in the environment or internal drives (e.g., hunger), the operation of which is outside of conscious awareness (Evans & Stanovich, 2013). Responses from the impulsive system are typically executed faster than those brought about by the rational system, which require greater effortful cognitive processing (Hofmann, et al., 2008; Kahneman, 2011; Strack & Deutsch, 2004). These models can account for the intention-behaviour gap as well as the role of habits and automatic processes in predicting behaviour (Sheeran, Gollwitzer, & Bargh, 2013).

TST draws together the strengths of social cognitive and self-regulatory models, along with current research into temporal and environmental influences on health behaviour; it explicitly addresses the intention-behaviour gap, and may therefore offer a more comprehensive model to explain healthy and unhealthy eating behaviour (Conner & Norman, 2015; Hall & Fong, 2007).

2.2 Temporal Self-Regulation Theory

2.2.1 Theory outline. In TST, Hall and Fong (2007) integrate previously separate areas of psychological, biological, and economic research into a framework to explain health promoting and health risk behaviours (Figure 2.1). The model includes motivational and volitional processes. In the motivational sphere, intentions (representing an individuals' conscious expressions of the direction and intensity of their motivation to engage in a behaviour; Ajzen, 1991) are hypothesised to be determined by beliefs about the connectedness (i.e., likelihood), valence (i.e., positive or negative nature) and timing (e.g., proximal/close in time or distal/further away in time) of anticipated outcomes of an action. TST proposes that individuals are more likely to intend to pursue behaviours that they believe are likely to have positive, immediate consequences (Ainslie, 1975; Hall & Fong, 2007; Shapiro, 2005; Schwarzer, 2008).

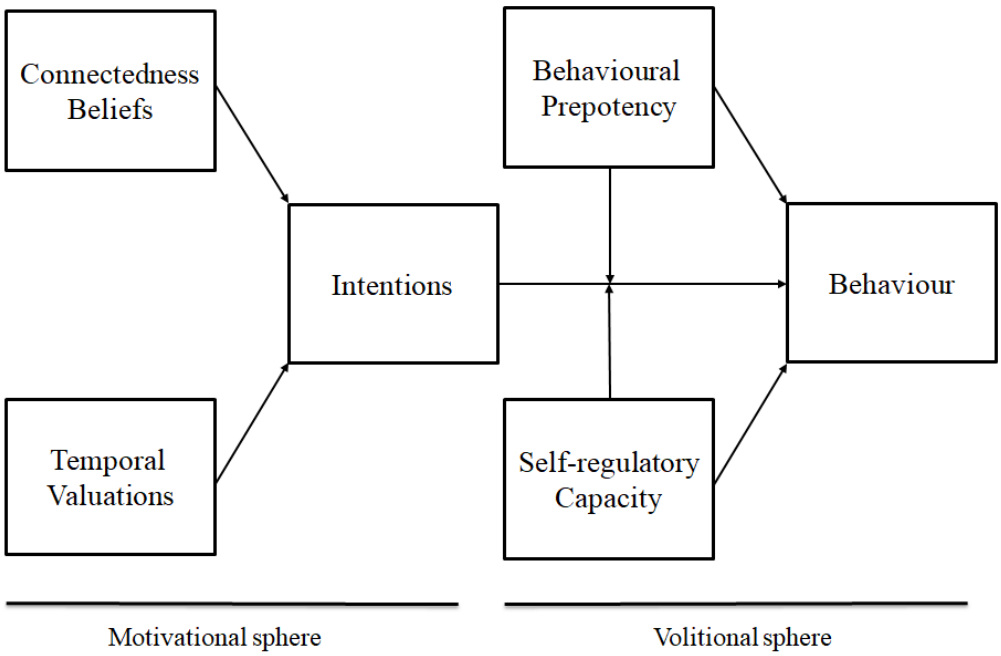

Figure 2.1. Temporal Self Regulation Theory (Hall & Fong, 2007).

In the volitional sphere of TST, intention is hypothesised to be a proximal determinant of behaviour (Hall & Fong, 2007). Hall and Fong explicitly recognise that intention is not a perfect predictor of behaviour and integrate two further direct predictors of behaviour within the model; namely, i) behavioural prepotency (the individual's default response based on past behaviour, habits, internal states, and cues to action in the environment) and ii) self-regulatory capacity (the underlying cognitive processes and physiological energy that influence an individual's ability to regulate their behaviour, especially in accordance with long-term goals and interests; Hall & Fong, 2007). TST further proposes that behavioural prepotency and self-regulatory capacity moderate the relationship between intention and behaviour. For example, cues (e.g., in the environment) that elicit undesirable prepotent (dominant) responses should weaken the intention-behaviour relationship, because prepotent responses are typically fast and automatic, and may influence behaviour before reflective processing of intentions, which is typically slower and more cognitively demanding (Orbell & Verplanken, 2015; Strack, & Deutsch, 2004). In contrast, cues that trigger prepotent responses in line with the desired behaviour should strengthen the intention-behaviour relationship. Self-regulatory capacity enables the control of desired behaviour and inhibition of undesired behaviour, and is used to aid in the translation of intentions to behaviour in environments that are not supportive of behavioural enactment (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012; Hall & Fong, 2007).

The rest of this chapter will describe the constructs within TST in more detail and explore the evidence for the key relationships outlined in the model.

2.2.2 Social cognitive beliefs. Connectedness beliefs refer to the perceived likelihood that an action will bring about a specified outcome, and can be measured through the extent to which participants endorse statements such as "If I eat chocolate then I will gain weight". Outcomes that are perceived as more likely are hypothesised to have a larger effect on

intentions than outcomes perceived as less likely to happen (Hall & Fong, 2007). Valence beliefs refer to the perceived positive or negative nature of outcomes (Hall & Fong, 2007), e.g., "If I eat chocolate then it will taste nice" versus "… taste disgusting". Individuals are theorised to trade-off the positive consequences ('pros') and negative consequences ('cons') of behaviour with the aim of finding out which course of behaviour is likely to produce the most favourable outcomes (Hall & Fong, 2007; Schwarzer, 2008).

Timing beliefs refer to when in time the outcomes are perceived to occur, e.g., "If I eat chocolate then I will be happy now" versus "… in the future". Drawing on economic theories of and research into temporal discounting (e.g., Ainslie, 1975; Chapman & Elstein, 1995; Lowenstein & Thaler, 1989), Hall and Fong (2007) propose a hyperbolic relationship, such that outcomes perceived as occurring close in time would be more salient, more highly valued by the individual, and influence intentions disproportionately more than outcomes perceived to occur later in time.

Connectedness beliefs and temporal valuations (i.e., valence and timing beliefs) help to explain undesirable eating patterns because eating foods high in saturated fat, sugar, and salt, such as chocolate or crisps, are typically associated with immediate positive outcomes, such as pleasant tastes that humans are drawn to (Deliens, Clarys, de Bourdeaudhuij, & Deforche, 2014; Drewnowski, 1997) and which, according to TST shape intentions more than the long-term (less certain and potentially more negative) consequences, e.g., weight gain or health complications from overconsumption (Hall & Fong, 2007). In contrast, eating healthy foods, such as an apple or a salad, is typically associated with immediate negative outcomes, e.g., inconvenience in preparing the food or high price, which according to TST will shape intentions more than beliefs about the long-term health benefits (Hall & Fong, 2007; Herbert, Butler, Kennedy, & Lobb, 2010). Theory suggests a general tendency for humans to value immediate gratification (e.g., Lowenstein & Thaler, 1989). However, there are individual

differences and those who focus on (or place value on) delayed graitification are more likely to intend to act in a healthful way (Boyd & Zimbardo, 2005). Beliefs about the expected outcomes of behaviour, and their relationship to intention, have been tested via the construct of 'outcome expectancies' within the Health Action Process Approach (Schwarzer, 2008)[2]. For example, Renner and Schwarzer (2005) measured beliefs about the likelihood of positive outcomes of eating a diet that is low in fat but high in fibre in members of the general population (N = 1782, age range 14 to 87 years old). Participants were asked the extent to which they believed that the dietary pattern would make them feel physically attractive, feel mentally better, and experience no or reduced weight issues. Renner and Schwarzer (2005) found that people who intended to eat healthfully had significantly higher expectancies that they would experience positive outcomes from this dietary pattern than those who did not intend to adopt the dietary pattern, mean 8.9 (SD = 2.6) versus 6.3 (SD = 2.5).

In a recent meta-analysis of 108 studies, outcome expectancies showed an average (bias-corrected) correlation of r_+ = .35 with intention, and predicted a variety of behaviours through intentions (Zhang, Zhang, Schwarzer, & Hagger, 2019). Research specifically shows that expectancies about the likelihood of the positive consequences of dietary behaviours, such as eating a low fat and high fibre diet or meeting F&V consumption guidelines have a moderate effect on intentions to eat healthfully (Schwarzer & Renner, 2000; Schwarzer et al., 2007). Based on his research, Schwarzer (2008) proposed that it would be sufficient to measure only expectations about the likelihood of positive outcomes and that it would not improve the prediction of intentions if negative outcome expectancies were included. In line with this proposal, research conducted with 1072 students at 8 Chinese universities found that only positive but not negative outcome expectancies were significantly correlated with intention to improve diet quality (Zhang et al., 2018). However, another study conducted with

[2] Other psychological theories, such as self-efficacy theory (Bandura, 1997) and the transtheoretical model (Prochaska & DiClemente, 1984), propose that expectancies about outcomes are direct predictors of behaviour and therefore do not test if this relationship is mediated by intentions, as hypothesised in TST.

a sample of 679 military conscripts found that beliefs in the connectedness of both positive and negative outcomes predicted dietary intentions; greater perceived physical wellbeing predicted stronger intentions to consume F&V, and greater perceived weight gain predicted stronger intentions to avoid fat (Hankonen, Kinnunen, Absetz, & Jallinoja, 2013). This latter finding supports the proposal of TST that the valence of expected outcomes of behaviour (both positive and negative) can be an important determinant of intentions to pursue that behaviour (Hall & Fong, 2007).

The evidence cited above indicates that beliefs about the consequences of action are consistent predictors of intention to eat healthfully in adult populations, although it is worth noting that the statistical significance of outcome expectancies can vary with different content of the beliefs and may be influenced by socio-demographic factors such as age, gender, social class, and level of education. For example, Traill, Chambers, and Bulter (2011) found that good health (as a likely outcome of a high quality diet) was valued more by older respondents (aged 50+) than by younger respondents, whereas 18-34 year olds placed more importance on looking good (appearance) than did the older group. These two outcomes were viewed as more important by females than by males, and by those from higher than lower social classes (Traill et al., 2011). Research has also found that women with lower educational attainment (GCSEs or below) expected more negative outcomes from following healthy eating guidelines than did women with higher educational attainment (above GCSEs) and there was a direct association between expecting fewer benefits and poor diet quality in women with a lower level of education whereas path modeling did not show a significant association for those with a higher level of education (The Food Choice Group, 2011).

The measures of outcome expectancies used in the research cited above, assessed beliefs about the likelihood and/or valence of outcomes, but did not include a measure of when in time the outcomes were expected to occur. There is little research that directly tests

the prediction of TST that the perceived short-term outcomes of behaviour will influence intentions more than the anticipated long-term outcomes. In one study testing this idea, Onwezen, Van't Riet, Dagevos, Sijtsema, and Snoek (2016) measured the extent to which participants agreed that consequences of eating snacks (other than fruit) would be present over the short or long term. The outcomes were grouped into consequences for health (e.g., "eating snacks is on the short-term/long-term bad for health"), appearance (e.g., "eating snacks is bad for weight on the short-term/long run") and social norms (e.g., "eating snacks directly/in the long run disapproved of by family"), as well as functional consequences (e.g., "eating snacks provides energy to reach short-term/long-term goals"). It was found that belief in the consequences of eating snacks (other than fruit) being present in the long-term explained more variance in intentions not to eat too many snacks (i.e., intentions to pursue more healthful behaviour) than did belief in the consequences occurring in the short-term (Onwezen et al., 2016). This appears to be in contrast to the prediction of TST and theories of temporal discounting that propose that immediate outcomes are disproportionately valued above longer-term outcomes (Hall & Fong, 2007). However, in their second study, Onwezen et al. (2016) found that a general disposition to focus on future consequences was correlated with higher intentions to eat more healthfully. In addition, studies have found that those who have a tendency to focus more on the future (i.e., long-term) rather than the immediate consequences of a behaviour had stronger intentions to eat F&V (Mullan, Allom, Brogan, Kothe, & Todd, 2014) and weaker intentions to eat fast food (Dunn, Mohr, Wilson, & Wittert, 2011). These findings suggest that the timing of perceived outcomes may be related to intentions, however, further research is needed to directly test predictions based on TST.

Overall, there is evidence that beliefs about the connectedness, valence, and timing of outcomes that are perceived to be associated with healthful eating can influence intentions to

eat or avoid certain foods/food groups. However, studies that simultaneously consider all three hypothesised determinants of intention are needed as a test of TST.

2.2.3 Intentions. TST proposes that intention is a direct predictor of behaviour (Hall & Fong, 2007) and can be measured by the strength with which an individual endorses statements such as "I intend to each chocolate" or "I intend to *avoid* chocolate". Intentions may change over time and it is proposed that stronger intentions, with greater stability over time, are stronger predictors of behaviour (Cooke & Sheeran, 2013; Hall & Fong, 2007).

There is consistent evidence from prospective studies that intention predicts both healthy and unhealthy eating behaviour (e.g., Blanchard et al., 2009; Brug, de Vet, de Nooijer, & Verplanken, 2006; Collins & Mullan, 2011; de Bruijn, 2010). For example, intention to eat 5 portions of F&V per day over the next week was found to explain 11% of variance in F&V consumption measured the following week for a sample of 216 university students (Blanchard et al., 2009). Similarly, Collins & Mullan (2011) found that intentions predicted 13% of variance in F&V consumption measured 2 weeks later, and intentions to snack every day explained 29% of variance in unhealthy snack consumption in a student sample.

The relationship between dietary intentions and behaviour is upheld in meta-analyses of correlational and prospective studies, which indicate a medium sized, robust effect (r_+ = 0.38 - 0.45; Guillaumie, et al., 2010; McEachan, et al., 2011; McDermott, Oliver, Svenson, et al., 2015; Shaikh, Yaroch, Nebeling, Yeh, & Resnicow, 2008; Sleddens et al., 2015). Interestingly, McDermott, Oliver, Svenson, et al. (2015) found that there appeared to be higher consistency between behaviour and intentions to choose a healthy food (r_+ = .43, N = 7676, k = 21) than intentions to avoid an unhealthy food (r_+ = .28, N = 6518, k = 10). However, the researchers did not code for behavioural prepotency or self-regulatory capacity,

which according to TST may have moderated the between intention and behaviour relationship (Hall & Fong, 2007).

2.2.4 Behavioural prepotency. The second direct predictor of behaviour outlined in TST is behavioural prepotency, which can be measured by assessing (the frequency of) past behaviour, habits, and the presence of cues that trigger the behaviour as a prepotent/dominant response (Hall & Fong, 2007, 2010). In line with TST, evidence demonstrates that past behaviour frequency (i.e., how often someone has carried out the same behaviour in the past, e.g., daily or several times per week) has a moderate-to-strong correlation with future behaviour (r_+ = .39, Ouellette & Wood, 1998). Moreover, multiple studies show that past behaviour predicts healthful eating patterns (e.g., Åstrøsm & Rise, 2001; Blanchard et al., 2009; Collins & Mullan, 2011; Danner, Aarts, & de Vries, 2008; Wong & Mullan, 2009). There is also evidence for the proposed moderation effect as there are studies which show that intention is less predictive of future behaviour as the frequency of past behaviour increases (e.g., Ouellette & Wood, 1998). However, this moderation effect has not been found in all studies (e.g., Danner et al., 2008) and theorists argue that the consistency between past and future behaviour indicates that the behaviour is stable over time, but does not explain the underlying processes that bring about this consistency, therefore, past behaviour has limited power as an explanatory construct (Ajzen, 1987).

Another measure of behavioural prepotency is habits, which are mental representations of behavioural tendencies[3] that are automatically elicited when a specific context is encountered and have been formed when the behaviour was repeated in that stable context (Bargh, 1990; Lally, van Jaarsveld, Potts, & Wardle, 2010; Verplanken & Orbell, 2003). Strong habitual behaviours can be differentiated conceptually and empirically from those that have simply been performed frequently in the past; habits also have high

[3] It is also possible to have habitual patterns of thought, but this thesis will focus on habits of behaviour, which are specified in TST (Hall & Fong, 2007).

automaticity whereas that need not be true for frequently repeated behaviours (Conner & Norman, 2015; Orbell & Verplanken, 2015) and research demonstrates that habit and past behaviour are independent predictors of eating behaviour (e.g., de Vries, Eggers, Lechner, van Osch, & van Stralen 2014).

Some researchers, for example Danner et al. (2008), have assessed habits through a measure of past behaviour multiplied by context stability, i.e., the time, place, and situation/circumstances (such as the weather or the presence of other people) in which the behaviour is performed. It was found that for the behaviours of snacking and drinking milk, habit was a significant predictor and moderated the intention-behaviour relationship such that intentions to consume the food/drink predicted behaviour when habit strength was weak, but did not when habits to perform the behaviour were strong (Danner et al., 2008). This interaction effect, which was hypothesized in TST (Hall & Fong, 2007), was not present when analyses were run for past behaviour and context stability separately, which supports the importance of the construct of habit in predicting behaviour. However, Conner and Norman (2015) argue that measures of context stability assess the situation that has led to the formation of the habit, rather than the habit itself.

An alternative way to assess a habit is to measure the degree of automaticity of behaviour (i.e., how easily the behaviour is performed without thinking or without having to consciously remember; Gardner, Abraham, Lally, & de Bruijn, 2012). Gardner, Abraham, et al., (2012) found that habit automaticity predicted behaviour and that a habit to consume snacks impeded the translation of intentions to avoid unhealthy snacks into behaviour (i.e., when individuals had strong habits of eating snacks they were less likely to act on their intentions to avoid snacks). In addition, Verplanken & Orbell (2003) suggest that self-identity is an aspect of habits, for example, that the individual would feel weird not performing the habit or they feel that performing the habit is typical of them.

The constructs of past behaviour frequency, automaticity and self-identity can be measured through the Self Report Habit Index (Verplanken & Orbell, 2003). In a meta-analysis of 13 studies, it was found that habit strength (as measured by the Self Report Habit Index) was correlated with both healthy and unhealthy eating (r_+=.41; Gardner, de Bruijn, & Lally, 2011). Research by de Bruijn (2010), with a sample of 538 students, further demonstrated that scores on the Self Report Habit Index moderated the relationship between intentions to consume fruit and fruit consumption behaviour, suggesting that strong congruent habits make eating behaviour less intentional. However, the Self Report Habit Index may be unsuitable for assessing habits within a TST model as it shows overlap with past behaviour as a means to measure behavioural prepotency and researchers have criticised the addition of self-identity as beyond the concept of habits (Conner & Norman, 2015; Gardner, de Bruijn, & Lally, 2012). Using a measure of past behaviour as well as the Self-Report Habit Index Automaticity subcale overcomes this problem of overlap.

A final measure of behavioural prepotency suggested by Hall and Fong (2007) is cues (e.g., internally generated such as hunger, or external in the environment) that can elicit prepotent responses that are consistent or inconsistent with an individual's goal and therefore can support or discourage behaviour in line with intentions (Hall et al., 2015). Biological drives such as hunger or thirst are powerful drivers of food and drink consumption behaviours and can bring about behaviour when external cues that trigger hunger/thirst or enable food/drink consumption may look very different (Hall & Fong, 2007; Hull, 1943). In an ecological momentary analysis study over 2 days, participants (118 female students) were three times more likely to report eating in the current hour if they were also hungry (Tomiyama & Mann, 2009). In addition, positive or negative mood states were related to significantly lower food consumption in the current hour and high consumption in the following hour (Tomiyama & Mann, 2009). Food cravings, which are typically experienced

as intense thoughts of or desires for specific types of food are another internal cue that have been found to increase food consumption, especially the consumption of sugary and/or fatty foods, such as chocolate (Layfay et al., 2001; Richard, Meule, Reichenberger, & Blechert, 2017).

External cues can also influence that type and quantity of food eaten. Wansink (2004) suggests that environmental influences on food consumption can be divided into those present in the eating environment and those present in the food environment. The eating environment includes, (i) the atmosphere (e.g., lighting, temperature, smells, and sounds), (ii) the effort required to consume food or the ease of access and convenience of consumption, (iii) the presence of others, who can dictate social norms for food consumption and can also divert attention away from the eating experience, and iv) distractions in the eating environment that could initiate eating in the absence of hunger, extend consumption, or obscure consumption and feelings of fullness/satiation (Wansink, 2004). The food environment includes, i) how salient the food is (e.g., the sight or smell of food can trigger consumption; Wadhera & Capaldi-Phillips, 2014), ii) the structure and variety of foods available, since an increase in perceived variety is associated with increased consumption, iii) the size of food packages and portions, iv) stockpiling of food, which is easy to access within the home and salient if the stockpile is large, and v) the shape of plates, glasses, and bowls that can lead to incorrect estimates of the quantity of food consumed (Wansink, 2004). Furthermore, evidence indicates that those with a higher sensitivity to food cues in the environment report greater food consumption than those with a lower sensitivity (Verhoeven et al., 2012).

Cues interact with prepotent responses to determine behaviour, for example, the context of a cinema can trigger the habit of eating popcorn and lead to greater consumption

than when the same popcorn is served in a meeting room environment that is not typically associated with eating popcorn (Neal, Wood, Wu, & Kurlander, 2011).

2.2.5 Self-regulatory capacity. Within TST, self-regulatory capacity is the final direct predictor of behaviour, which encompasses the underlying cognitive processes and physiological energy that influence the trait and state ability of an individual to successfully regulate their behaviour (Hall & Fong, 2007). Self-regulatory capacity enables the 'top down' control of behaviour (in contrast to the 'bottom up', reflexive direction of behaviour via prepotent responses). In line with recent research into self-regulation[4] (e.g., de Ridder et al., 2012; Duckworth & Kern, 2011; Friese, Hoffmann, & Wänke, 2008), TST proposes that self-regulation requires deliberate suspension of undesired prepotent responses to act in line with long-term goals. For example, if an individual holds a goal to eat healthfully, they will have to resist any temptation to eat their favourite chocolate cake, especially if the environment facilitates acting on prepotent responses, such as if the individual saw a cake on the kitchen counter. Therefore, Hall and Fong hypothesise that when there is sufficient self-regulatory capacity available, it can aid in the translation of intentions into behaviour.

Hall and Fong (2007) propose that biologically determined self-regulatory capacity can be measured through tests of executive functioning, i.e., specific cognitive abilities that exert control over behaviour in a top-down manner (Hall & Fong, 2007). There is no agreement in the research literature over how many separable executive functions exist or how they should be categorised (Baggatta & Alexander, 2016; Packwood, Hodgetts, & Tremblay, 2011; Suchy, 2009). One categorisation, which has been widely used is Miyake et al.'s (2000) three dimensions of executive functions; (i) inhibitory control or response inhibition, which stops an individual from acting on their undesirable prepotent responses, (ii)

[4] Self-regulatory capacity can be viewed within the larger construct of self-regulation, which also entails the processes by which an individual sets goals (to regulate behaviour, thoughts, and emotions), monitors progress towards those goals, and takes action to achieve the goal or to change the goal based on perceived progress (Baird, Webb, Martin, & Sirois, 2017; Carver & Scheier, 1982).

updating or working memory, which is responsible for monitoring if current behaviour is in line with the goal state, and (iii) shifting or cognitive flexibility, which is required to alternate between tasks. Executive functioning is typically assessed through behavioural performance measures such as the Stop-Signal Task (inhibition dimension; Logan, Schachar, & Tannock, 1997), operation span tasks (e.g., OSPAN, working memory dimension; Forster et al., 2015) or the Wisconsin Card Sorting Test (flexibility dimension; Milner, 1963). Self-regulatory capacity may also be measured through self-report of general trait ability to control behaviour or avoid acting on temptations (e.g., the Brief Self-Control Scale; Tangney, Baumeister, & Boone, 2004).

Evidence from cross-sectional and prospective studies suggests that self-regulatory capacity, when measured by executive functioning or self-control scales, is associated with initiating (or approaching) healthy eating and inhibiting (or avoiding) unhealthy eating (e.g., de Ridder et al., 2012; Jansen et al., 2009; Jasinska et al., 2012; Limbers & Young, 2015; Lowe, Hall, & Staines, 2014). For example, Allom and Mullan (2014) found that updating (akin to working memory) measured by a behavioural task predicted the consumption of F&V over the following week, such that those with better working memory ate more F&V. In addition, the dimension of inhibitory control predicted saturated fat intake such that those with lower inhibitory control reported that they had eaten more saturated fat over the following week (Allom & Mullan, 2014). In a large study of almost 2,800 adults, Keller, Hartmann, and Siegrist (2016) found that the Brief Self-Control Scale significantly predicted diet quality above socio-demographic factors. However, other studies have failed to find a significant relationship between self-regulatory capacity and healthful eating (e.g., Haynes, Kemps, & Moffit, 2015; Hofmann, Fries, & Roefs, 2009; Wang et al., 2015).

Hall and Fong (2007) hypothesise that self-regulatory capacity can aid the translation of intentions into behaviour. Analysis on data from a survey completed by 1072 university

students, found that self-regulatory capacity (measured by the Brief Self-Control Scale) moderated the relationship between intentions and behaviour such that those with higher self-control were more likely to act on their intentions to restrict intake of high calorie foods (Hagger et al., 2019). Individuals with stronger executive functions, for example, inhibition control, have also been found to show higher consistency between their intentions and behaviour; those with poor inhibition control ate more chocolate despite their intention not to (Allan, et al., 2010) and less F&V despite their intentions to (Hall, Fong, Epp, & Elias, 2008). In contrast those with high self-regulatory capacity were better able to act in line with their intentions (Allan et al., 2010; Hall et al., 2008), which supports the moderation hypothesis within TST. However, Mullan et al. (2014) found that intention was a direct predictor of F&V consumption and saturated fat intake for a sample of 152 university students, but self-regulatory capacity did not moderate this link. Therefore, further research is necessary to explore self-regulatory capacity as a moderator of the relationship between intention and behaviour for healthy and unhealthy eating.

It should also be noted that situational factors such as mood, stress, or fatigue, can have an impact on self-regulatory capacity when these factors temporarily deplete or increase resources, such as physiological energy, and thereby impair or boost an individual's ability to perform on tasks requiring self-regulatory capacity (Baumeister, Muraven & Tice, 2000; Hall & Fong, 2007).

2.2.6 Environmental contingencies. The social and physical environment can present barriers and enablers to performance of an intended behaviour, these may be cues the influence behaviour, but can also be factors that change the balance of the (real and perceived) costs and benefits over time, and therefore support or discourage performance of the behaviour (Hall & Fong, 2007; Hall & Fong, 2015). For example, if an who individual intends to eat healthfully and is experiencing internal cues of hunger opens their fridge and

see a melon, which requires preparing before it can be eaten (i.e., it has immediate costs) and a slice of cheesecake that can be eaten straight from the package (i.e., it has fewer immediate costs), then they may eat the cheesecake. However, if the same individual visits the desserts section at a buffet bar and sees melon cut into chunks (i.e., no immediate cost of preparation) and a slice of cheesecake (also with no costs of preparation), then they are more likely to act on their intention to choose the melon over the cheesecake if they view the foods as equally filling and tasty. In the first scenario, the costs of eating the melon was more proximal and thus was unsupportive of the behaviour of healthy eating, whereas in the second scenario the immediate costs of both behaviours were equal and eating the melon had greater long-term benefits, therefore the environment was more supportive of the intended behaviour (Hall & Fong, 2007).

Hall and Fong (2007) hypothesise that behaviour is likely to be predicted by intention and behavioural prepotency in situations that support the desired behaviour being performed. This is because the default response is likely to be congruent with the intention. In contrast, behaviour will be predicted by intentions and self-regulatory capacity in situations that do not support the desired behaviour being performed. This is because the default response in this situation would be counter to intentions, and thus self-regulatory capacity could aid in inhibiting the urge to perform the undesired response and to organise enactment of the desired response. These specific predictions of TST with regards to the effect of the environment were tested by Booker and Mullan (2013). A sample of 152 Australian university students completed measures of intentions to maintain a healthy lifestyle (which included eating F&V and breakfast), behavioural prepotency (i.e., past behaviour), self-regulatory capacity (i.e., the executive functions of planning, response inhibition, and decision making) and the perceived supportiveness of the environment (i.e., the extent to which physical, sensory, social, internal, and emotional factors influenced their healthy

lifestyle behaviours). In line with predictions it was found that behavioural prepotency predicted the cluster of healthy behaviours for students who perceived the environment was highly supportive, while self-regulatory capacity (the dimensions of planning and response inhibition) and intention predicted healthy behaviours among students who perceived the environment was low in support.

2.2.7 Feedback loops. TST proposes that the performance of behaviour can influence expectancies (i.e., connectedness, valence, and timing beliefs) about the outcomes of future performance and will feed into the 'past behaviour' dimension of behavioural prepotency (Hall & Fong, 2007). For example, if an individual tried a new healthy food such as whole grain bread and enjoyed it, then they may have more positive expectations about the outcomes (e.g., taste and satisfaction) that would occur if they ate whole grain bread again in the future. This process may help to explain the maintenance of behaviour (Hall & Fong, 2007). In addition, behaviour may have an influence on an individuals' brain structure and/or functioning and consequently on self-regulatory capacity (Davidson, Jones, Roy, & Stevenson, 2019). These feedback loops are not highly elaborated by Hall & Fong (2007; 2010), but their inclusion within TST improves upon the previous theories of behaviour explained at the start of the chapter, which do not account for the influence of behaviour on expectations about, or performance of, future behaviour.

2.3 Conclusion

Theoretical models can be used as a means to understand and change health behaviour. Conceptually, TST has a number of advantages over other models of health behaviour (e.g., the theory of planned behaviour); TST (i) provides a temporal perspective, (ii) can account for the intention-behaviour gap, (iii) incorporates impulsive processes, and (iv) acknowledges environmental influences on behaviour. To date, however, researchers have not adequately explored the determinants of intention as outlined by TST (i.e., including

beliefs about when in time the perceived positive and negative outcomes of the behaviour would occur). Evidence on the hypothesised predictors of behaviour is stronger, although there have been conflicting findings regarding if and how behavioural prepotency and self-regulatory capacity moderate the relationship between intentions and eating behaviour. These research questions will be addressed in Study 1, which is reported in the next chapter.

Chapter 3. Using Temporal Self-Regulation Theory to Understand Healthy and Unhealthy Eating Intentions and Behaviour

Lifestyle factors, including diet, have the potential to improve or compromise long-term health; the evidence, outlined in Chapter 1, indicates that eating fruit and vegetables (F&V) protects against chronic diseases, including cardiovascular disease and diabetes, while eating too much saturated fat, sugar, and salt exacerbates health problems (GBD 2017 Diet Collaborators, 2019; Scientific Advisory Committee on Nutrition, 2019). On average, adults in the United Kingdom (UK) do not meet the UK guidelines (outlined in the Eatwell Guide) to eat 5 portions of F&V per day and exceed recommended levels of saturated fat, sugar, and salt (Roberts et al., 2018). Interventions to improve dietary patterns are therefore needed, which requires an understanding of the determinants of eating behaviours, especially those that are potentially amenable to change, such as peoples' beliefs. The present research, described in this chapter, investigated whether Temporal-Self Regulation Theory (TST; Hall & Fong, 2007) can help to understand the determinants of healthy and unhealthy eating intentions and behaviour.

This chapter reports a belief elicitation study to identify modal salient beliefs about the perceived outcomes of healthy (i.e., eating F&V) and unhealthy (i.e., eating snacks high in saturated fat, sugar, and salt) behaviour, as well as cues in the environment that could trigger a prepotent food consumption response. The results of this pilot study were used to develop four measures used in the main study, which tested the extent to which the constructs outlined in TST (Hall & Fong, 2007) predicted eating intentions and behaviour for F&V and unhealthy snack consumption.

3.1. Belief elicitation study: University student's beliefs about eating healthy and unhealthy foods

TST (Hall & Fong, 2007) proposes that beliefs about the connectedness (i.e., likelihood), valence (e.g., positive or negative) and timing (e.g., immediate or in the future) of anticipated outcomes of a behaviour influence intentions to engage in that behaviour. Chapter 2 outlined evidence which suggests that beliefs about positive and negative outcomes of behaviour predict enactment through intentions (e.g., Hankonen et al., 2013; Schwarzer & Renner, 2000; Zhang et al., 2019) and that a tendency to value immediate over long-term outcomes predicts intentions to eat less healthfully (e.g., Dunn et al., 2011). However, separate research streams have focused on (i) the perceived connectedness and valence of outcomes (e.g., outcome expectancies within the Health Action Process Approach; Schwarzer, 2008) on intentions, and (ii) beliefs about the timing of outcomes (e.g., literature on temporal discounting, Ainslie, 1975). In order to test TST as a predictor of intentions to pursue eating behaviours, all three of the hypothesied determinants (i.e., connectedness, valence, and timing beliefs) need to be considered simultaneously.

Moreover, research has found that the extent to which expectancies predict intentions varies depending on socio-demographic factors, such as education level (explained in Chapter 2). This difference in predictive utility may be because different populations have different salient beliefs about the target behaviour and its outcomes, which may not have been adequately measured by researchers who often select outcomes of interest based on the research literature rather than consulting with the target population about their beliefs (e.g., Evans et al., 2015; The Food Choice Group, 2011). The present research aimed to address this issue by eliciting salient beliefs (Fishbein & Ajzen, 2010) about the outcomes of eating healthy (i.e., F&V) and unhealthy (i.e., snacks high in saturated fat, sugar, and salt) foods in terms of the valence (positive/negative) and timing (short-term/long-term) of the outcomes, in a target population of university students in the UK.

The present belief elicitation study focused on university students because the transition to university is typically accompanied by changes in students' social and physical environments that are associated with reduced F&V consumption, increased 'junk food' consumption, and less healthful eating patterns (Deforche, Van Dyck, Deliens, & De Bourdeaudhuij, 2015; Graham, Pelletier, Neumark-Sztainer, Lust, & Laska, 2013; Park & Papadaki, 2016; Tanton, et al., 2015); for example, a limited budget to spend on food, increased responsibility for preparing meals, and the generally low quality of food available in vending machines on campus. A 2011 study of almost 4,000 students at 7 universities in the UK found that although around 70% of those surveyed reported that healthy eating was "very important" for them, only 16.5% of females and 11.3% of males ate the recommended 5 or more portions of F&V per day, while almost 40% ate sweets (e.g., candy or chocolate) several times per day (El Ansari et al., 2011). The increased consumption of food that is energy-dense but low in micro-nutrients may be related to the micronutrient deficiencies (e.g., vitamin D, calcium, iron and folate) that have been found in samples of university students in the UK (Farhat, Lees, Macdonald-Clarke, & Amirabdollahian, 2019). Transition to life at university may also be accompanied by psychological changes, for example, increased stress and distress from major life changes, new academic demands, and responsibility for finances (Beswick, Koutsopoulou, Miles, Slaa & Barkham, 2010). Evidence from a systematic review suggests that stress can impact on dietary patterns; students were more likely to eat unhealthy foods and less likely to healthy foods as their level of stress increased (Lyzwinski, Caffery, Bambling, & Edirippulige, 2018). The health habits that are established in early adulthood often persist into later life and have the potential to impact upon long-term health outcomes (Friedman et al., 2008; Wiium, et al., 2015). Students are therefore an important target for behaviour change interventions to improve diet and reduce the burden of chronic disease (as discussed in Chapter 1).

Previous research using focus groups of students has investigated outcomes and cues to action in terms of the perceived 'benefits' (i.e., positive outcomes) and 'barriers' (which could otherwise be described as factors that shift the prepotent response to non-action of the target behaviour or an alternative response). For example, Herbert et al. (2010) found that students in the UK reported that beliefs about improved health and appearance (e.g., weight) encouraged them to eat F&V, but negative factors such as perceived high cost of healthy eating, inconvenience, a lack of cooking and planning skills, sensory issues (e.g., not liking the taste or foods spoiling) and living circumstances (e.g., on campus or not close to outlets that sold healthy foods) were perceived as barriers to meeting recommendations to eat 5 portions of F&V per day. Similar findings were reported in a sample of Canadian students, with additional factors such as disease prevention and feeling better cited as benefits of eating a healthy diet, and a lack of choice as an additional barrier (House, Su, & Levy-Milne, 2006). A prospective study on 139 university students in the UK found that the factors of inconvenience, limited finances, lack of time, and competing priorities were correlated with F&V consumption one week later; lower intake was reported in those who experienced the barriers more strongly (Evans et al., 2015). However, the researchers did not test if these factors were correlated with intention to eat F&V, as hypothesised in TST (Hall & Fong, 2007).

Research suggests that factors that form barriers to healthy eating can be drivers of the consumption of unhealthy foods, such as snacks that are high in fat, sugar, and salt, or convenience ready-meals/take-aways. In a scoping review of 34 studies on young adults aged 18-24 years (70% of studies sampled university students), Munt, Partridge and Allman-Farinelli (2017) found that the perceived enjoyable taste, convenience (in terms of easy access to food and lack of/minimal cooking requirements), and low cost were cited by participants as reasons that they ate unhealthy foods. Stress and pressure surrounding

academic achievement also increased unhealthy food consumption for some participants (Munt et al., 2017). The studies also reported that although young adults perceived there to be negative long-term health consequences of eating unhealthily, they were not concerned or motivated to reduce their intake of unhealthy foods (e.g., Hattersley, Irwin, King, & Allman-Farinelli, 2009). Moreover, social factors were reported to play a substantial role in encouraging the consumption of unhealthy foods, such as the belief that peers ate unhealthy snacks and drank sugar sweetened beverages and the availability of unhealthy foods at social events (e.g., Jensen et al., 2014).

However, there is limited research into students beliefs about the negative outcomes of and enablers to consumption of healthy foods, conversely, few qualitative studies have directly investigated the perceived short- and long-term outcomes of unhealthy eating (independent of their relationship to healthy eating). The present study, therefore, aimed to investigate university students' beliefs about the outcomes of eating F&V and unhealthy snacks in relation to the valence (positive/negative) and temporal proximity (immediate/short-term or non-immediate/long-term) of the outcomes, with free-responses provided by the participants. Factors that may cue the consumption of each type of food were also investigated.

3.1.1 Method.

Participants and procedure. Participants were recruited to take part in a short online questionnaire on beliefs about different eating behaviours. An advertisement for the study was posted on a university webpage for students interested in taking part in research studies. Participation was voluntary and there was no incentive to participate. Ethical approval was granted by the university ethics committee.

After providing consent, participants answered a series of open-ended questions on their beliefs about eating F&V and unhealthy snacks; the order of presentation of the blocks

of questions about healthy and unhealthy eating was counterbalanced. Unhealthy snacks were defined to participants as all foods consumed between the three main meals (i.e., breakfast, lunch, dinner) containing a high amount of fat, sugar, and/or salt and a low amount of micronutrients (Verhoeven, et al., 2012). Examples of unhealthy snacks included crisps, chocolate, confectionery, biscuits, pastries, and ice-cream, but not nuts and seeds or dried fruit. Twenty-seven students completed the questionnaire (age $M = 24.23$, $SD = 5.80$; $n = 18$ (66.7%) female).

Measures.

Demographics. Participants reported their age, gender, and living conditions (e.g., in private self-catered accommodation or with parents).

Beliefs. Questions to assess (i) participants' beliefs about outcomes of eating F&V or unhealthy snacks, given the valence (positive or negative) and temporal proximity (i.e., immediate or non-immediate), and (ii) percieved environmental cues, were developed based on standard methods within the health behaviour literature for eliciting model salient beliefs (Fishbein & Ajzen, 1975, 2010). Four open-ended questions were used to elicit salient (connected) beliefs about the short-term and long-term, positive and negative outcomes of eating F&V. For example, "What are the immediate or short-term (i.e., while eating or shortly after) positive outcomes of you eating fruit and vegetables?". Two questions asked about perceived environmental cues that could elicit or prevent a prepotent consumption response; "What factors and circumstances make it easier or enable you to eat fruit and vegetables?", "What factors and circumstances make it difficult or prevent you from eating fruit and vegetables?". Participants also answered these same questions in relation to the target behaviour of eating unhealthy snacks.

Data analysis. Participants beliefs were identified within the free-response data collected (Fishbein and Ajzen, 2010); the responses are show in Appendix 3A. First, the

primary researcher coded the raw data to provide a description of the key beliefs in each response. If the meaning of a whole response could not be interpreted, it was assigned to the category "uncoded". Second, codes with similar themes were clustered together where possible to develop the coding scheme; any code that was not reported by 2 or more participants was re-coded to "uncoded". Thirdly, all of the responses were coded (using the coding scheme) by second researcher. There was a high level of agreement (95%) and any disagreements were resolved jointly through discussion and the generation of new codes when appropriate. The frequency of each code was calculated to identify the most commonly cited beliefs.

3.1.2 Results. Tables 3.1 and 3.2 summarise the key themes that were identified for beliefs about the short- and long-term, and positive and negative outcomes of eating F&V and unhealthy snacks, as well as participant's perceptions of the environmental cues that elicit or prevent a prepotent consumption response. The frequency of each theme, as well as an example quote, is provided in the tables.

***Salient beliefs about eating fruit and vegetables*.** Twenty-nine beliefs about the short-term negative outcomes of eating F&V were recorded. One third (9) of respondents cited feelings of hunger or not feeling full; this was the most common short-term negative outcome. The remaining three themes were reported by a smaller number of participants and included unenjoyable or bad taste, digestive problems, and dissatisfaction. Interestingly, 7 (26%) participants reported that they could think not think of any short-term negative outcomes of eating F&V. Five responses were uncoded, one of which was because the participant reported a positive outcome ('feel good').

All participants reported that they believed that eating F&V had positive short-term outcomes. Of the 42 beliefs about the short-term positive outcomes of eating F&V, mental health benefits were the most commonly reported and were cited by 13 (48%) participants.

Beliefs relating to mental health benefits were varied and included perceptions of better focus and motivation, feeling refreshed, and good or positive feelings. The second most frequently cited belief about the short-term positive outcomes of eating F&V was physical health benefits, e.g., more energy, boosted immune system, and good digestion. Feeling healthy (as opposed to mentioning specific mental or physical health benefits that could be classified into the themes above) was the third most frequent belief, cited by 9 (33%) participants. The remaining themes of likeable taste and feeling full or satisfied hunger were reported by a smaller number of participants and were a mirror of the short-term negative beliefs (i.e., bad taste, not feeling full, and feeling dissatisfied).

Sixteen (56%) participants reported that they believed there were no long-term negative outcomes of eating F&V. Four beliefs about long-term negative outcomes of eating F&V were coded, each reported by 2 or 3 (< 11%) participants; hunger or the desire to eat more, high sugar consumption, bowel problems, and dental problems (e.g., acid damage to teeth). Conversely, all participants reported that eating F&V had long-term positive outcomes. All but two participants (93%) reported feeling healthier or better health; a theme which also included beliefs related to lower risk or prevention of chronic diseases (e.g., diabetes). The specific health outcomes of better skin/hair/nails, better digestion and higher energy levels were identified and given separate codes. Weight loss or having a slim body was reported by 9 (33%) participants. Mental health and wellbeing was reported as a long-term positive outcome of eating F&V by 4 (15%) participants.

Fourty-one beliefs were reported about factors or circumstances that make it easier or enable the consumption of F&V and may therefore increase consumption as a prepotent response. The most commonly reported themes were cheap/affordable cited by 9 (33%) participants, and easy or wide availability cited by 8 (30%) participants. Beliefs were varied and there were a further 6 codes assigned to the free-response data, which included having

them at home, convenience, and having recipes. Five responses were uncoded because they were not expressed by 2 or more participants. All of the codes are shown in Table 3.1.

The salient beliefs about cues in the environment that prevent the consumption of F&V or make it more effort were less varied than beliefs about the supporting factors; 4 codes were assigned. High price and preparation time/effort were the most commonly cited beliefs; 12 (44%) participants endorsed each belief. The remaining themes were produce spoiling (e.g., going mouldy if over ripe or being damaged in a bag) cited by 7 (26%) participants, along with wanting to eat unhealthy foods and the unavailability of desired F&V, both cited by 4 (15%) participants. Four (15%) participants reported that they experienced no cues or factors that made it more effort or prevented them from eating F&V.

Salient beliefs about eating unhealthy snacks. Thirty-one beliefs about the short-term negative outcomes of eating unhealthy snacks were recorded. The most frequently reported belief, held by 12 (44%) respondents, was negative mental wellbeing, labelled feelings of guilt or regret. Themes relating to negative physical outcomes of feeling ill, overly full or bloated cited by 7 (26%) participants, and energy drop or tiredness cited by 6 (22%) participants, were also reported as short-term negative outcomes of unhealthy snacking. Each of the remaining three themes were reported by 2 (7%) respondents; disruption of main meals, craving or consuming more unhealthy snacks, and more hunger. Four (15%) respondents reported that they perceived no short-term negative outcomes of eating unhealthy snacks.

The most frequently reported belief about the short-term positive outcomes of unhealthy snacking was coded as positive emotions, such as happiness, enjoyment or satisfaction cited by 16 (59%) participants. The second most reported belief about the short-term positive outcomes of eating unhealthy snacks, cited by 13 (48%) participants, was more energy or a sugar rush. Beliefs about pleasant tastes and feeling full and satiated were also

common; cited by 12 (44%) and 9 (33%) participants respectively. Positive social interactions were cited by 2 (7%) participants, for example, sharing snacks with friends. Only one participant reported that there were no short-term positive outcomes because they try not to eat them.

All participants reported that they perceived unhealthy snacking to have long-term negative outcomes. Weight gain/being overweight and health issues, such as heart problems, diabetes or dental problems were reported by over half of participants; 18 (66%) and 16 (59%) respectively. Negative feelings such as guilty or regret were reported by 8 (30%) participants to be experienced a long time after consumption of unhealthy. Feeling sluggish or tired and disrupted meal patterns were also reported, which were the reserves of the codes given to the beliefs about the short-term negative outcomes of eating unhealthy snacks.

More than half of participants (16 (59%) repondents) reported that they could not think of any, or believed that there were no, long-term positive outcomes of eating unhealthy snacks. Four codes were assigned to the free responses and each reported by 2 (7%) to 4 (15%) participants; a happier life, positive memories (e.g., 'related to having a good time with family and friends'), a balanced or varied diet, weight gain, and cheaper prices.

Participants reported more cues that made it easier or enabled them to eat unhealthy snacks (57 beliefs were coded) than factors that made it difficult for or prevented them from eating unhealthy snacks (37 coded beliefs). All participants reported factors that supported them eating unhealthy snacks whereas 6 (22%) reported that there were no cues or circumstances that made it difficult or prevented them from unhealthy snacking. Beliefs about the cues that elicited or prevented a prepotent response of eating unhealthy snacks were varied; 7 and 8 codes (respectively) were assigned. The most frequently reported factors that supported the consumption of unhealthy snacks were wide availability/accessibility cited by 16 (59%) participants, convenience cited by 13 (48%) participants, and low price cited by 12

(44%) participants. The most frequently reported factor that did not support the consumption of unhealthy snacks was lack of availability (e.g., not having them in the house) cited by 8 (30%) participants. This was followed by desire to be healthy or avoid sickness, knowledge of the negative consequences, and having alternative healthy options, such as fruit available in the fridge at home or taking a packed lunch to university. All of the codes are shown in Table 3.2.

3.1.3 Discussion. This study investigated beliefs about the positive and negative outcomes of eating F&V and unhealthy snacks that could occur over a short or long time-frame, in a sample of university students from the UK. The present study increases knowledge of the content of specific beliefs that may be used to assess the hypothesised predictors of intention (i.e., connectedness, valence, and timing beliefs) within the TST framework (Hall & Fong, 2007).

Overall, the results supported previous research in student populations, which identified factors such as better health and appearance (e.g., weight or clear skin) as positive outcomes of healthy eating, and cost, taste preferences, inconvenience, and time as negative outcomes or barriers (e.g., Herbert et al., 2010; House, et al., 2006). However, the present study adds details in regards to the time frame over which these outcomes are perceived to occur. Eating F&V has been classified as a distal benefit behaviour (Collins & Mullan, 2011) and our results confirm this; over half of participants did not report a long-term negative outcome of eating F&V, but all participants reported one or more long-term benefits. More beliefs were coded for positive than negative outcomes over both time-frames. This suggests that students believe that eating F&V has mostly positive effects; both in the short-term and long-term. These findings suggest that further research is necessary to quantify the strength of these beliefs and determine their influence on intentions, because it would be expected that students would meet F&V recommendations (which, on average, they currently do not) if the

Table 3.1.

Codes for all elicited beliefs for fruit and vegetable consumption showing item, frequency and an example quote (N = 27)

Belief type / theme (F&V)	Frequency	Example quote
Short-term negative outcomes (F&V)		
Feelings of hunger or not feeling full	9	‘not filling enough’
None	7	‘I don’t think there are any’
Uncoded	5	‘feel good for eating healthy food’
Unenjoyable or bad taste	3	‘I do not like the taste of some e.g. asparagus’
Digestive problems	3	‘sometimes my stomach gets too acidic after eating fruit’
Dissatisfaction	2	‘sometimes I feel dissatisfied after eating them’
Short-term positive outcomes (F&V)		
Mental health benefits	13	‘feel healthier and refreshed, happy because I’ve eaten well’
Physical health benefits	11	‘more energy’
Feeling healthy	9	‘feel healthy/ nourished’
Likeable taste	5	‘tastes good’
Feeling full or satisfied hunger	4	‘not hungry’
None	0	
Uncoded	0	

Long-term negative outcomes (F&V)		
None	16	‘none’
Hunger or the desire to eat more	3	‘not filling’
High sugar consumption	3	‘too much fruit can result in too much sugar’
Bowel problems	2	‘large quantities could cause bowel problems’
Dental problems	2	‘acid damage to teeth from eating fruit’
Uncoded	2	‘Fruit and veg, especially more exotic kinds, is quite expensive’
Long-term positive outcomes (F&V)		
Feeling healthier or better health	25	‘improves your general health’
Weight loss or a slim body	9	‘I am ... slimmer’
Better skin, hair and nails	6	‘good skin’
Mental health and wellbeing	4	‘better wellbeing resulting in greater ... mental health’
Better digestion	2	‘better digestive system’
Higher energy levels	2	‘having more energy’
None	0	
Uncoded	0	

Perceived supportive cues in the environment (F&V)		
Cheap/ affordable	9	‘they aren’t particularly expensive’
Easy or wide availability	8	‘having a fruits and veggie store near the house’
Uncoded	5	‘I like them’
Having them at home	4	‘I have a large stock of fruit and veg at home’
Convenience	3	‘pre prepared veg, less hassle’
Upbringing and habits	3	‘my upbringing (mum always encouraging to eat fruit and vegetables)’
Nice taste	2	‘general appreciation of the taste of fruit’
Having time to prepare and/ or cook	2	‘have time to plan and cook proper meals’
Intention or desire to eat healthy/ F&V	2	‘desire to be healthier’
Having recipes	2	‘having recipes at hand to try new combinations/ flavours’
None	1	‘nil’
Perceived unsupportive cues in the environment (F&V)		
High price	12	‘find it somewhat expensive’
Preparation time and effort	12	‘more hassle to prepare’
Produce spoiling	**7**	‘easily damaged – somewhat inconvenient’
Wanting to eat unhealthy foods	4	‘sometimes I just want to eat pizza & cookies’
None	4	‘personally I do not have any difficulties in doing so’
Uncoded	0	

Table 3.2.

Codes for all elicited beliefs for unhealthy snack consumption showing item, frequency and an example quote (N = 27)

Belief type / theme (unhealthy snacks)	Frequency	Example quote
Short-term negative outcomes unhealthy snacks)		
Feelings of guilt or regret	12	‘guilty feeling’
Feeling ill, overly full or bloated	7	‘if I eat too much I feel sick’
An energy drop or tiredness	6	‘become tired or more hungry after not long’
None	4	‘nothing’
Disruption of main meals	2	‘may stop you from eating your main meals properly’
Crave or consume more unhealthy snacks	2	‘crave more sugary foods’
More hungry	2	‘more hungry not long after’
uncoded	1	‘feeling thirsty after salty food’
Short-term positive outcomes (unhealthy snacks)		
Positive emotions	16	‘I enjoy eating them’
More energy or a sugar rush	13	‘energy buzz/ sugar rush’
Pleasant tastes	12	‘they taste great’
Feeling full and satiated	9	‘they are filling’
Positive social interactions	2	‘Can be shared with friends’
none	1	‘none’
uncoded	0	

Long-term negative outcomes (unhealthy snacks)		
Weight gain or being overweight	18	‘will put on weight’
Physical health issues	16	‘poor overall health’
Negative feelings	8	‘guilt and a bit of depression’
Feeling full and sluggish or tired	6	‘feel lethargic if I’ve eaten too many’
Disrupted meal patterns	2	‘ruins meal routines’
Uncoded	1	‘Want the snack even more’
None	0	
Long-term positive outcomes (unhealthy snacks)		
None	16	‘I can’t think of any’
A happier life	4	‘some indulgence, so happier’
Uncoded	3	‘Might want to gain weight?’
Positive memories	2	‘can remember how good it was when you ate the snacks’
Lack of hunger	2	‘Full at the end of every day and not getting hungrier’
A balanced or varied diet	2	‘potentially balanced diet if it were done in moderation’

Perceived supportive cues in the environment (unhealthy snacks)		
Wide availability and accessibility	16	‘stocked everywhere’
Convenience	13	‘take little preperation’
Low price	12	‘they are generally cheaper’
Reasons to justify snacking	5	‘if it’s a celebration, eg Christmas, birthdays’
Taste	4	‘good taste’
Desire for unhealthy snacks	4	‘the “lust” after them’
The presence of others	3	‘people offer them around in social situations’
None	0	
Uncoded	0	
Perceived unsupportive cues in the environment (unhealthy snacks)		
Lack of availability	8	‘not having them in the house’
None	6	‘none’
Alternative healthier options	5	‘if there is fruit and other healthy options of food available’
Desire to be healthy or avoid sickness	5	‘trying to focus on improving my diet’
Knowledge of negative consequences	5	‘overindulging in them will potentially lead to health problems’
Self-control	2	‘I rarely allow myself to eat unhealthy snacks’
Social pressure to avoid unhealthy snacks	2	‘if other people are enjoying healthy snacks around me’
Not buying unhealthy snacks	2	‘having to actively buy the product’
Negative mental states	2	‘the knowledge of how guilty i’ll feel afterwards’
Uncoded	0	

frequency of positive beliefs was a strong determinant of intentions and subsequent behaviour (Hall & Fong, 2007; Ajzen, 1991). Moreover, the number of perceived cues that increased or decreased consumption as a prepotent response were almost equal.

In contrast, eating unhealthy snacks has been classified as an immediate-hedonic (rewarding) behaviour (Collins & Mullan, 2011). The beliefs reported by students in the present study align with this view since more short-term positive than negative outcomes were reported, but more long-term negative than positive outcomes were identified. Almost 20 more perceived cues that enable consumption were coded that those that make consumption more difficult, which may increase behavioural prepotency and explain why unhealthy snacking is high in the student population (El Ansari et al., 2011).

The present results also align with previous findings which show that factors perceived as a negative outcome or a barrier for certain participants may be perceived as a positive outcome or enabler for others (Sogari, Velez-Argumedo, Gómez, & Mora, 2018). In the present study, 3 participants reported that they did not like the taste of F&V, while 5 reported that F&V tasted good. In addition, some participants believed that they would experience both positive and negative emotions (e.g., enjoyment or guilt) as short-term outcomes of eating unhealthy snacks. These appear to be conflicting outcomes and it is possible that the outcome that participants perceive as the most likely will have a stronger influence on intentions to eat or avoid eating unhealthy snacks (Hall & Fong, 2007). Furthermore, the belief elicitation study demonstrated that there is cross-over between what participants perceive as outcomes of food consumption and cues that increase or decrease behavioural prepotency (e.g., the taste of F&V and negative mental states perceived after the consumption of unhealthy snacks were reported as both outcomes and cues). This may speak to the feedback loops proposed in TST whereby previous experience with a behaviour

influences expectancies about the outcomes of performing the behaviour in the future (Hall & Fong, 2007).

Overall, the belief elicitation study identified university students beliefs about the outcomes of eating healthy (i.e., F&V) and unhealthy (i.e., snacks high in saturated fat, sugar, and salt) foods in relation to the valence (positive/negative) and temporal proximity (immediate/short-term or non-immediate/long-term) of the outcomes. Perceived cues that increase or decrease food consumption as a prepotent response were also identified in the target population. These modal salient beliefs can be used in future research investigating the determinants of intention for university students within a TST framework (Hall & Fong, 2007).

3.2. Study 1: Predicting healthy and unhealthy eating intentions and behaviour using TST

TST has a number of strengths as a model of health behaviour and has been described as a "viable, integrative framework for contemporary research" (Webb & Sheeran, 2010, p.1). As detailed in Section 2.2, TST synthesises ideas from psychology, behavioural economics, and neuroscience into a comprehensive model that seeks to explain the 'intention-behaviour gap' (Sheeran, 2002) as well as temporal and environmental influences on behaviour (Hall & Fong, 2007). By so doing, TST identifies determinants of eating behaviours that can be targeted in behaviour change interventions (Bruyneel & Dewitte, 2016; Duckworth, Gendler & Gross, 2016; Enriquez-Geppert, Huster, & Herrmann, 2013; Lally et al., 2010; Reuter et al., 2010). However, previous research has tended to focus on the predictive ability of one or two factors from TST in isolation (for a review, see Conner & Norman, 2015).

The present research therefore sought to investigate the extent to which TST could be used to understand healthy (F&V) and unhealthy (snacking) eating intentions and behaviour.

It was hypnothesised, based on TST that: (i) intentions will be predicted by beliefs about the outcomes of the behaviour, (ii) behaviour will be predicted by intentions, behavioural prepotency (past behaviour, habit, and perceived cues) and self-regulatory capacity, and (iii) behavioural prepotency and self-regulatory capacity will moderate the relationship between intention and behaviour.

3.2.1 Method.

Participants and procedure. Potential participants on a 'volunteers' list at a university in the UK were emailed with details of the study and a link to the online questionnaire. The details were also posted on a webpage for students interested in participating in research. Participation was voluntary, but was incentivised by the offer of a £50 prize draw for those who responded at both time points. Ethical approval was granted by the university ethics committee.

After providing consent, participants were randomised to complete questionnaires on either F&V or unhealthy snack consumption. Subsequently, participants read either the Eatwell Guide recommendations to eat 5 portions of F&V per day or to limit unhealthy snacking. An 'unhealthy snack' was defined to participants as all foods consumed between the three main meals (i.e., breakfast, lunch, and dinner) containing high levels of fat, sugar and/or salt, and low levels of micronutrients (Verhoeven et al., 2012). Examples of portion sizes were given for each of the behaviours. Participants then reported their beliefs regarding the likelihood, valence, and timing of potential outcomes of eating F&V/unhealthy snacks before completing measures of their intention to eat F&V/unhealthy snacks, habit strength, past behaviour, perceived cues in the environment, and self-control. Finally, participants reported demographic details. One week later participants were emailed a link to the follow-up questionnaire which assessed their consumption of F&V or unhealthy snacks over the previous week.

Baseline questionnaires were completed by 267 students, although nine were subsequently excluded from data analysis due to extreme values (> 3 *SD*s above the mean) on past behaviour or behaviour at follow-up. For F&V consumption, the baseline sample included 133 participants (age $M = 23.92$, $SD = 7.40$; $n = 91$ (68.4%) female), of whom 115 (86.5%) responded at follow-up. For unhealthy snacking, the baseline sample included 125 participants (age $M = 23.10$, $SD = 5.18$; $n = 91$ (72.8%) female), of whom 109 (87.2%) responded at follow-up. Power analyses indicated that the sample sizes would be sufficient to detect the following small-to-medium effect sizes (Cohen, 1992) in the regression analyses predicting F&V intentions, $f^2 = 0.09$, F&V intake, $f^2 = 0.15$, snacking intentions, $f^2 = 0.10$, and snacking behaviour, $f^2 = 0.16$, with 80% power and alpha set at 0.05.

Measures.

Demographics. Participants reported their age, gender, height, weight, nationality, ethnicity, and living conditions (e.g., with parents or in catered university accommodation).[5]

Beliefs. Participants were asked about their beliefs concerning the outcomes of eating F&V or unhealthy snacks. These outcomes were identified though an elicitation study (reported in Section 3.1). For each behaviour, three of the most frequently cited short-term negative, long-term negative, short-term positive, and long-term positive outcomes were included in the questionnaire for the main study. The order of presentation of the beliefs was counter-balanced.

For eating F&V, the short-term negative beliefs that participants were asked about were not feeling full, unenjoyable or bad taste, and digestive problems, while beliefs about

[5] Associations between demographic variables and eating intentions and behaviour were tested for F&V intake and unhealthy snacking. Gender was significantly associated with F&V intentions; females reported higher intentions than males, $t(131) = 3.51$, $p < .001$. Nationality was significantly associated with unhealthy snacking intentions; British participants had higher intentions than those from other countries, $t(123) = .3.40$, $p < .001$. Age was significantly correlated with snacking behaviour; snacking at follow-up decreased with increasing age, $r(109) = -.19$, $p = .04$. No other associations were significant. The regression analyses were re-run controlling for these variables, but this had no effect on the predictive significance of variables specified by TST and so analyses without these variables are reported for ease of interpretation.

mental health benefits, physical health benefits, and feeling healthy were the short-term positive outcomes. Beliefs about the long-term negative outcomes were high sugar (consumption) levels, bowel problems, and dental problems, while weight loss or a slim body, mood and quality of life, and being healthy/avoiding health problems were the short-term outcomes (the latter outcomes were re-worded from the codes 'being healthy or better health' and 'mental health and wellbeing' because these were considered too similar to the short-term positive outcomes). For eating unhealthy snacks, the short-term negative beliefs were feelings of guilt or regret, feeling ill or bloated, and an energy drop, while the positive short-term outcomes were positive emotions, increased energy or a sugar rush, and pleasant taste. The long-term negative outcomes were weight gain or being overweight, physical health issues, and negative feelings (e.g. dissatisfaction); an example was given for 'negative feelings' to differentiate it from the feelings of guilt or regret as a short-term negative outcome. Finally the long-term positive outcomes were a happier life, positive memories, and a balanced diet.

Beliefs about the *connectedness* (i.e., likelihood) of each outcome were measured by presenting participants with the stem "How likely are you to experience the following outcomes from eating fruit and vegetables/unhealthy snacking?" followed by a list of the potential outcomes. Participants rated the likelihood of each outcome on a scale from 1 (*very unlikely)* to 7 (*very likely*).

Beliefs about *valence* of the outcomes were measured by presenting participants with the stem "If you were to experience the following outcomes from eating fruit and vegetables/unhealthy snacks, to what extent would they be *bad (1) or good (7)?"* followed by a list of the potential outcomes.

Beliefs about the *timing* of the outcomes were measured by presenting participants with the stem "If you were to experience the following outcomes from eating fruit and

vegetables/unhealthy snacks, when do you think you would experience them?" followed by a list of the potential outcomes. Participants responded on a scale from 1 (*immediately or shortly after*) to 7 (*non-immediately or a long time after*).

Composite measures were created by averaging the strength of the connectedness beliefs for short-term negative, long-term negative, short-term positive, and long-term positive outcomes, respectively (for each behaviour). Averages were computed for the perceived valence and the perceived timing of each belief. Visual inspection was used to identify the beliefs with positive and negative valence and to classify these as short-term or long term for the sample (see Appendix 3B; Table 3B.1. for F&V and Table 3B.2. for unhealthy snacking). For F&V consumption 4 beliefs were re-classified in terms of perceived timing; high sugar levels and better mood/quality of life were re-classified as a short-term outcomes, digestive problems and physical health benefits were re-classified as long-term outcomes. For unhealthy snacking 2 beliefs were re-classified; negative feelings (such as dissatisfaction) were re-classified as short-term outcome, whereas an energy drop was re-classified as a long-term outcome.

Following the re-classification of the connectedness beliefs according to their perceived valence and timing for the study sample, paired samples t-tests confirmed that the outcomes that were classified as short-term were rated as significantly more immediate than those classified as long-term for both F&V consumption (M_{ST} = 3.13, *SD* = 1.04; M_{LT} = 4.83, *SD* = 0.85), $t(132) = 18.68$, $p < .001$), and unhealthy snacking (M_{ST} = 2.46, *SD* = 0.93; M_{LT} = 4.42, *SD* = 0.85), $t(125) = 21.20$, $p < .001$). Similarly, outcomes classified as positive were rated as significantly more positive than outcomes classified as negative for F&V consumption (M_{POS} = 6.34, *SD* = 0.73; M_{NEG} = 2.42, *SD* = 0.76), $t(132) = 34.36$, $p < .001$), and unhealthy snacking (M_{POS} = 5.23, *SD* = 1.10; M_{NEG} = 2.20, *SD* = 0.83), $t(125) = 22.71$, $p < .001$).

Intentions. Three items were used to measure intentions (e.g., "I intend to eat unhealthy snacks over the next week"). Responses were given on 7-point scales with high scores indicating more positive intentions. The internal reliability was high in both samples (F&V $\alpha = .95$; unhealthy snacks $\alpha = .89$).

Behavioural prepotency. Three measures of behavioural prepotency were included. First, *past behaviour frequency* was assessed by asking participants to estimate their F&V or snack consumption, e.g., "In the past week, how many portions of fruit and vegetables did you eat on an average day?", "In the past week, how many times did you eat unhealthy snacks on an average day?" (Evans, et al., 2015).

Second, *habit strength* was measured using the four-item Self-Report Behavioural Automaticity Index (SRBAI; Gardner, Abraham, et al., 2012). Participants rated the extent to which eating F&V or unhealthy snacks was, for example, something that they 'do automatically' (rated 1 = *strongly disagree* to 7 = *strongly agree*). Items were averaged to form a score for habit strength where higher scores indicated stronger habits. The scale shows good predictive, construct, and convergent validity with the Self-Report Habit Index (Verplanken & Orbell, 2003) from which it was derived (Galla & Duckworth, 2015; Gardner Abraham, et al., 2012) and the internal reliability of the SRBAI was high in both samples (F&V $\alpha = .90$; unhealthy snacks $\alpha = .90$).

Third, for each behaviour, *perceived cues* in the environment that elicit a prepotent consumption response were assessed by asking participants how frequently (1 = *less than once per week* to 7 = *several times per day*) they experienced three factors that support the behaviour (e.g., "cheap price", "wide availability", "high convenience"). The cues were identified though the elicitation study (reported in Section 3.1). Higher scores indicated that cues that trigger a prepotent consumption response were perceived more often in the environment.

Self-regulatory capacity. The 13-item Brief Self-Control Scale (Tangney, et al., 2004) was used to measure self-regulatory capacity. Participants were asked to rate the extent to which the statements reflected their typical behaviour, for example "I have a hard time breaking bad habits" (reverse coded) or "I am good at resisting temptations" (rated 1 = *not at all* to 5 = *very much*). The Brief Self-Control Scale has good psychometric properties, higher ecological validity than performance based measures of self-regulatory capacity (De Ridder et al., 2012; Limbers & Young, 2015), and had high internal reliability in both samples (F&V $\alpha = .84$; unhealthy snacks $\alpha = .82$).

Future behaviour. At follow-up, the amount of F&V or unhealthy snacks consumed over the prior week was measured in the same way as past behaviour at baseline.

Analyses. For each behaviour (F&V consumption and unhealthy snacking), the data was analysed in four stages. First, the descriptive statistics (means, standard deviations) were computed for all TST variables and the measures of behaviour. Second, correlations were conducted between the TST variables and intention and behaviour. Associations between demographic variables and intention/behaviour were also assessed using correlations and t-tests or ANOVAs as appropriate. Third, a regression analysis was conducted to examine how well connectedness beliefs with different valence and temporal orientations explained intention. Fourth, to test the predictive utility of TST for explaining eating behaviour, intention, habit, past behaviour, perceived cues in the environment, self-control, the intention-behavioural prepotency interaction terms (intention*habit, intention*PB, intention*cues) and the intention-SRC interaction term were entered into a multiple regression analysis. All of the predictor variables were mean centred and interaction terms were created by multiplying these variables (Field, 2013). Simple slopes analysis was conducted to decompose significant interaction terms (Aiken & West, 1991). The variables were entered at the same time because

TST suggests interplay between the factors in determining behaviour in a given situation and does not propose an order in which they should be tested (Hall & Fong, 2007).

3.2.2 Results

F&V Intake. Participants reported eating an average of 3.39 portions of F&V per day at follow-up (*SD* = 1.50, range = 0 - 8 portions), comparable to findings from previous studies with a sample of students where the average F&V consumption ranged from 2.2 to 3.8 portions per day (see Tanton et al., 2015).

Predicting F&V intentions. As shown in Table 3.3, beliefs about the short-term (i.e., mental health benefits, feeling healthy, and better quality of life) and long-term (i.e., physical health benefits, weight loss, and being healthy) positive outcomes were significantly and positively correlated with F&V intentions. Beliefs about short-term negative outcomes (i.e., not feeling full, bad tastes, and high sugar levels) were significantly and negatively correlated with F&V intentions. The correlation between beliefs about long-term negative outcomes (i.e., dental, bowel, and digestive problems) and F&V intentions was not significant.

In order to test whether TST could predict F&V intentions, beliefs regarding the short-term negative, long-term negative, short-term positive, and long-term positive outcomes of F&V were entered into a regression analysis. The model explained 22.4% of variance in intentions, $F(4,128) = 10.52$, $p < .001$; beliefs about short-term positive and negative outcomes were significant predictors. Thus, participants who believed that eating F&V would have short-term positive outcomes were significantly more likely to intend to consume F&V, while those who believed that there would be short-term negative outcomes were less likely to intend to consume F&V (see Table 3.4).

Table 3.3

Means, standard deviations and correlations between TST beliefs and intentions to consume F&V

	2.	3.	4.	5.	*M*	*SD*
1. Intention	-.25**	-.07	.45***	.35***	5.17	1.67
2. Short-term negative		.32**	-.12	-.05	3.40	0.87
3. Long-term negative			-.12	-.01	2.67	1.02
4. Short-term positive				.68***	5.65	0.98
5. Long-term positive					5.46	0.91

*Note. ** p < .01. *** p < .001*

Table 3.4

Regression analysis predicting intentions to consume F&V

	B	*SE B*	β
Short-term negative beliefs	-.44	.13	-.36**
Long-term negative beliefs	.02	.15	.02
Short-term positive beliefs	.41	.16	.25*
Long-term positive beliefs	.03	.16	.02

Note. $R^2 = .22$, $p < .001$. * $p < .05$. ** $p < .01$

Predicting F&V intake. Behaviour at follow-up was significantly correlated with intentions, habit strength, past behaviour, and perceived cues in the environment, but not with self-control (see Table 3.5). Individuals who reported higher F&V intake at follow-up tended to have more positive intentions, stronger habits, higher previous consumption frequency, and to perceive more cues in the environment that triggered F&V consumption. The regression model accounted for 64.4% of variance in F&V consumption, $F(9,104) = 20.88$, $p < .001$; intentions, past behaviour, and the interaction between intentions and past behaviour emerged as significant predictors (see Table 3.6).

Table 3.5

Means, standard deviations, and correlations between TST variables for F&V consumption

	2.	3.	4.	5.	6.	*M*	*SD*
1. Intention	.14	.52***	.42***	.41***	.65***	5.17	1.67
2. Self-control		.29**	.01	.12	.12	4.40	0.67
3. Habit strength			.46***	.37***	.50***	4.51	1.64
4. Past behaviour				.33***	.58***	3.76	1.84
5. Perceived cues					.39***	4.93	1.14
6. F&V						3.39	1.50

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3.6

Regression analysis predicting F&V consumption

	B	*SE B*	β
Intention	.35	.07	.39***
Self-control	-.07	.15	-.03
Habit	.06	.07	.07
Past-Behaviour	.43	.07	.49***
Cues	.12	.09	.09
Intention*Self-control	.07	.08	.05
Intention*Habit	-.01	.04	-.03
Intention*Past behaviour	.11	.03	.29***
Intention*Cues	.01	.01	.01

Note. $R^2 = .64$, $p < .001$. *** $p < .001$

Given the significant interaction between intentions and past behaviour, simple slopes were plotted to examine the intentions-behaviour relationship at low (mean - 1 *SD*), moderate (mean) and high (mean + 1 *SD*) levels of past behaviour (Aiken & West, 1991). There was a significant positive association between intentions and F&V intake at all levels of past behaviour. However, the slope of the line was steeper for high, $B = .53$, $t(113) = 10.87$, $p < .001$, and moderate, $B = .34$, $t(113) = 10.64$, $p < .001$, than for low levels of past behaviour, $B = .16$, $t(113) = 2.17$, $p = .03$. Thus, past behaviour moderated the intention-behaviour relationship; the relationship became stronger as the frequency of past behaviour increased.

Unhealthy snacks. Participants reported eating an average of 1.80 unhealthy snacks per day over the past week at follow-up (*SD* = 1.19, range = 0–5).

Predicting intentions to eat unhealthy snacks. As shown in Table 3.7, beliefs about short-term (i.e., pleasant taste, positive emotions, and a sugar rush) and long-term (i.e., a balanced diet, positive memories, and a happier life) positive outcomes were significantly and positively correlated with unhealthy snacking intentions. Beliefs about short-term negative outcomes (e.g., feeling guilty, ill, or negative emotions) were significantly and negatively correlated with unhealthy snacking intentions. The correlation between beliefs about long-term negative outcomes (e.g., weight gain, health issues, and energy drop) and unhealthy snacking intentions was not significant.

In order to test whether TST could predict intentions to eat unhealthy snacks, beliefs regarding the short-term negative, long-term negative, short-term positive, and long-term positive outcomes of unhealthy snacking were entered into a regression model. The model explained 17.5% of variance, with beliefs about the short-term positive and negative outcomes of unhealthy snacking emerging as significant predictors, $F(4,120) = 7.56$, $p < .001$.

Table 3.7

Means, standard deviations and correlations between TST beliefs and intentions to consume unhealthy snacks

	2.	3.	4.	5.	*M*	*SD*
1. Intention	-.37***	-.16	.27**	.21*	3.73	1.77
2. Short-term negative beliefs		.58***	-.04	-.19*	4.27	1.45
3. Long-term negative beliefs			.15	.01	4.21	1.18
4. Short-term positive beliefs				.49***	5.40	1.07
5. Long-term positive beliefs					3.39	1.05

Note. * $p < .05$. * $p < .01$. *** $p < .001$

Participants who anticipated short-term positive consequences of snacking had significantly higher intentions, whereas those who anticipated short-term negative outcomes had significantly lower intentions to snack. There were no other significant predictors (see Table 3.8).

Table 3.8

Regression analysis predicting intentions to consume unhealthy snacks

	B	*SE B*	β
Short-term negative beliefs	-.40	.16	-.21*
Long-term negative beliefs	.07	.14	.04
Short-term positive beliefs	.63	.18	.37**
Long-term positive beliefs	.17	.19	.09

Note. $R^2 = .18$, $p < .001$. * $p < .05$. ** $p < .01$

Predicting unhealthy snacking behaviour. The consumption of unhealthy snacks at follow-up was significantly and positively correlated with intentions (to consume unhealthy snacks), habit strength, and past behaviour, and was significantly and negatively correlated with self-control (see Table 3.9). The regression model accounted for 34.6% of variance in

behaviour, $F(9,99) = 5.81$, $p < .001$; however, only habit strength and past behaviour were significant predictors (see Table 3.10). Thus, participants with stronger unhealthy snacking habits and those who had eaten unhealthy snacks more frequently in the past were more likely to eat unhealthy snacks at follow-up.

3.2.3 Discussion

The present research investigated whether TST could be used to identify the determinants of, and thus be used to help understand, healthy and unhealthy eating intentions and behaviour. The variables identified by TST explained large, and significant, amounts of the variance in intentions to eat F&V and unhealthy snacks. Specifically, the findings indicated that beliefs about the likelihood of positive and negative short-term outcomes are important determinants of intentions. These findings support theories and research which suggests that the perceived immediate or short-term consequences are disproportionately valued in decision making compared to longer-term outcomes (e.g., Ainsle, 1975; Chapman & Elstein, 1995). The finding is in contrast to Onwezen et al. (2016; study 1) who found that more variance in intentions was explained by beliefs that the outcomes of eating unhealthy snacks would occur in the long-run than by beliefs that these outcomes would occur in the short-term. One difference between the studies is that the content was different for the short-term and long-term beliefs in the present study, whereas for each belief Onwezen et al. asked participants to rate the extent to which they thought the same outcomes would occur (i) in the short-term, and (ii) in the long-term. This difference in methodology may, in part, account for the difference in outcomes and future research could explore this distinction.

The beliefs about outcomes of behaviour selected for use in this study were taken from belief elicitation research in the same population of students (see Section 3.1); a method proposed by Fishbein and Ajzen (1975). This is a strength of the study because different factors may be salient for different population groups based on their knowledge and

Table 3.9

Means, standard deviations and correlations between TST variables for unhealthy snack consumption

	2.	3.	4.	5.	6.	*M*	*SD*
1. Intention	-.12	.21*	.38***	.21*	.22*	3.73	1.77
2. Self-control		-.37***	-.30**	-.30**	-.32**	4.38	0.66
3. Habit strength			.37***	.18*	.41***	3.00	1.64
4. Past behaviour				.21*	.50***	1.53	0.94
5. Perceived cues					.04	4.60	1.34
6. Snacking						1.80	1.19

Note. * $p < .05$. *$p < .01$. *** $p < .001$.

Table 3.10

Regression analysis predicting unhealthy snack consumption

	B	*SE B*	β
Intention	.01	.06	.00
Self-control	-.29	.18	-.16
Habit	.16	.07	.22**
Past-Behaviour	.45	.12	.37***
Cues	-.08	.09	-.08
Intention*Self control	.04	.10	.04
Intention*Habit	.01	.03	.02
Intention*Past-Behaviour	-.02	.07	-.02
Intention* Cues	.04	.05	.08

Note. $R^2 = .35$, $p < .001$** $p < .01$. ***$p < .001$.

experience with eating different foods (e.g., Traill et al., 2007). It is important to note that although the perceived valence of outcomes reported in the belief elicitation study was the same as reported by participants in the present (main) study, the perceived timing of outcomes differed. For example, participants in the belief elicitation study cited better mood and quality of life as a long-term positive outcome of eating F&V, whereas for participants in the main study this perceived outcome was classified as being more immediate. This difference in the perceived timing of outcomes may be due to the way in which the salient modal beliefs in the elicitation study were coded and presented to participants within the main study or due to differences in beliefs between those in the belief elicitation and main study.

Towriss (1984) argues that researchers should elicit salient beliefs from each individual in the study, rather than using salient model beliefs generated by the population to which the individual studied belongs (i.e., the method proposed by Fishbein and Ajzen, 1975). Few research studies test have this proposition, but there is some evidence from cross-sectional studies that individually generated beliefs may show stronger correlations with intentions to perform a range of behaviours (e.g., drinking milk and using condoms) than beliefs provided by the researchers (Agnew, 1998; Rutter & Bunce, 1989). However, Sutton et al. (2003) caution that asking individuals to generate their own beliefs may produce reactive effects on subsequent questions (especially when beliefs and intentions are measured at the same time point) and researchers must establish how many of the beliefs generated by the participants are salient. Moreover, Agnew (1998) found that there was an 80% overlap in the content of the salient modal beliefs that was generated by the individuals in the study and that was provided by the researchers based on an elicitation study, and 35% of respondents did not generate beliefs different to those provided by the researchers. It is unclear, therefore, if using individually generated salient beliefs is a better methodology than the one used in the

present study; future research could explore this question. In terms of testing TST, it is important to highlight again that participants' beliefs about the perceived connectedness, valence, and timing of outcomes should be tested within a study and not assumed on the basis of belief elicitation research.

Another important finding of the present study was that the variables specified by TST explained significant variance in participants' consumption of F&V and unhealthy snacks at follow-up. Different variables, however, predicted each behaviour; intentions and past behaviour predicted F&V intake, while habit strength and past behaviour predicted unhealthy snacking. Such findings are consistent with research showing that health behaviours with different characteristics have different determinants (Collins & Mullan, 2011). Specifically, unhealthy snacking is often thought of as habitual or impulsive and typically requires little time or organisation, while the consumption of F&V requires more planning and cooking skills (Caruso, Klein, & Kaye, 2014; Larson, Perry, Story, & Neumark-Sztainer, 2006). As such, it might be expected that unconscious processes including habits would play a stronger role in consumption of unhealthy snacks than F&V, whereas strong intentions and previous experience may promote F&V consumption (Verhoeven et al., 2012).

The present research also found that past behaviour strengthened the relationship between intentions and F&V. At first glance, this finding might appear contrary to research which suggests that intentions are *less* predictive when people have performed the behaviour frequently in the past (e.g., Ouellette & Wood, 1998). However, this positive interaction may be explained by the fact that intentions and past behaviour were *congruent* in the present research (i.e., both supported performance of the behaviour). In this situation, an individual may form goals or intentions by observing and interpreting their past behaviour; for example, if they have eaten F&V in the past then they may infer that they are a healthy person and intend to behave consistently in the future (Bem, 1972; Festinger, 1957; Webb & Sheeran,

2006). When the opportunity to act on their intention arises, the individual's desire to maintain a coherent self-identity and commitment to act in line with past behaviour can maintain the behaviour (Bech-Larsen & Kazbare, 2014; Fennis, Andreassen, & Lewis-Olsen, 2015). In contrast, past behaviour that is not in line with current goals is likely to undermine intentions and hinder behaviour change (Ouellette & Wood, 1998; Webb & Sheeran, 2006). The finding that past behaviour strengthened the relationship between intentions and F&V consumption could also be interpreted as preliminary evidence for the feedback loops suggested in TST by which observed behaviour influences connectedness, valence, and timing beliefs, which in turn influence intentions to engage in that behaviour in the future (Hall & Fong, 2007).

One surprising finding, given the predictions of TST, was that self-regulatory capacity did not predict either behaviour. One possible explanation may be that the Brief Self-Control Scale (Tangney et al., 2004) is not sufficiently sensitive to the particular dimensions of self-regulatory capacity that are relevant to specific eating behaviours. For example, research using measures of executive functioning based on task performance has found that F&V consumption is related to the dimensions of switching and updating, and unhealthy eating is related to inhibitory control (Allan et al., 2011; Allom & Mullan, 2014). In addition, the Brief Self-Control Scale assesses trait level self-regulatory capacity and does not measure state levels of self-control that might be important during eating-related decisions. For example, Vohs and Heatherton (2000) reported that individuals whose self-regulatory resources had been (temporarily) depleted consumed more ice cream in a subsequent taste test than those whose self-regulatory resources had not been depleted, consistent with the idea that state levels of self-regulatory capacity are important in controlling responses to tempting foods. Duckworth and Kern (2011) acknowledge the multiple aspects of self-control (including the general trait-like construct and executive functions) and suggest that self-control should,

therefore, be assessed through multiple measures. The present study only assessed self-control with one measure, but three dimensions of behavioural prepotency were assessed (i.e., past behaviour, habits, and cues to action), and these dimensions showed different relationships to the outcome of eating behaviour. Therefore, future research using TST to understand eating behaviour may consider assessing of self-regulatory capacity based on state-specific performance measures in addition to trait measures similar to the one used in the present study.

An alternative explanation for the finding that self-regulatory capacity was not predictive in the present research may be that self-regulatory capacity was not needed to direct behaviour because, overall, participants reported that they experienced cues in the environment as eliciting the behaviour as a prepotent response and facilitating performance of the behaviours. Indeed, Hall and Fong (2007) suggest that self-regulatory capacity is most likely to influence behaviour in contexts that *do not* support the behaviour. This prediction was tested by Booker and Mullan (2013) who found that self-regulatory capacity significantly predicted healthy lifestyle behaviours in those who viewed cues in the environment as unsupportive of the behaviours, but not in those who perceived cues in the environment as supportive.

Implications for interventions. The present findings have implications for interventions. For example, campaigns to promote healthy eating often focus on the long-term benefits of dietary choices (e.g., "Living Longer", Department of Health, 2016). However, the finding that beliefs about the short- rather than long-term outcomes of behaviour predicted intentions to eat both F&V and unhealthy snacks suggests that this may be an unsuitable strategy to change eating behaviours. Instead, the present findings suggest that campaigns may be more effective if they target beliefs about the likely short-term outcomes of behaviour. The content of such campaigns should, however, be considered

carefully. For instance, although short-term outcomes such as negative emotions (e.g., feelings of guilt or regret) have been shown to reduce unhealthy behaviour (Sandberg, Hutter, Richetin, & Conner 2016), they have also been linked to eating disorder psychopathology and unsuccessful weight management (Kuijer & Boycer, 2014; Sassaroli et al., 2005).

The finding that past behaviour significantly predicted eating behaviour also has implications for behaviour change interventions. For example, many interventions appeal to reasoned processes (e.g., by providing information or incentives, Herman & Polivy, 2011). However, these techniques may not be effective if behaviour is primarily driven by prepotent responses and is a relatively automatic process. An alternative strategy would be to change how people appraise their past behaviour. Rothman (2000) proposes that maintenance of behaviour primarily depends on perceived satisfaction with received outcomes (e.g., Kassovou, Turner, Hamborg, & French, 2014) and evidence suggests that asking people to reflect on past food choices that have made them feel positive and proud can be more motivating than reflecting on past food choices that have made them feel negative and guilty (Reynolds, Webb, Benn, Chang, & Sheeran, 2018). Interventions could, therefore, encourage individuals to reflect on the positive outcomes of their previous healthy eating behaviours in an effort to increase satisfaction and promote continued performance of the behaviour. This suggestion is in line with the feedback loops proposed in TST (Hall & Fong, 2007).

Limitations. A number of limitations mean that the above conclusions are made with some caution. First, a sample of students participated in the research, which means that the findings may not be generalisable to other samples (e.g., those who are more experienced in preparing food for themselves). Second, the self-report measures used in the present research may have led to socially desirable or inaccurate responses. The present research used measures that have shown to be reliable and valid and that are typically used in research in the field (e.g., the Brief Self-Control Scale); nonetheless, they could be combined with

alternative measures (e.g., the Stop Signal Task; Logan et al., 1997) in future research (Gardner, 2015; de Ridder et al., 2012). Third, the data in the present research is correlational. Future research could examine if *changes* in any of the components predict *changes* in behaviour to provide a stronger, experimental, test of TST, as has been provided in relation to other social cognition models (e.g., Sniehotta, 2009).

Conclusions. The present research found that the constructs specified by TST were able to explain significant variance in both healthy and unhealthy eating intentions and behaviours. Consistent with the predictions of TST, intentions to eat F&V and unhealthy snacks were influenced by beliefs about the likelihood of short-term outcomes of each behaviour. The findings, however, did not find support for all of the hypothesised relationships (e.g., self-regulatory capacity, measured via self-reported level of self-control, was not associated with the performance of either behaviour). Thus, in conclusion, the present research suggests that TST may be a useful framework for understanding the determinants of health behaviour, although, further research is required to replicate and extend the current findings by using alternative measures of self-regulatory capacity.

Chapter 4. Study 2: How do Different Measures of Self-Regulatory Capacity Relate to Eating Behaviour?

4.1 Introduction

Chapter 3 reported Study 1, which tested constructs of Temporal Self-regulation Theory (TST; Hall & Fong, 2007) as predictors of healthy (i.e., eating fruit and vegetables (F&V)) and unhealthy (i.e., eating snacks high in saturated fat, sugar, and salt) eating behaviour. As hypothesised based on TST, it was found that intentions to eat F&V and prior consumption of F&V (i.e., past behaviour) were significant direct predictors of the amount of F&V consumed one week later. The hypothesised moderation effect of past behaviour on the intention-behaviour relationship was also found (Hall & Fong, 2007); the relationship between intention and F&V consumption was stronger when participants had consumed higher levels of F&V in the past. Unhealthy snacking behaviour was predicted by past behaviour and habit strength, which provided further evidence for the role of behavioural prepotency in the direction of behaviour (Hall & Fong, 2007).

However, data from Study 1 showed that, in contrast to the predictions based on TST, self-regulatory capacity as measured by the Brief Self-Control Sale (Tangney et al., 2004) was not correlated with F&V intake, was not a significant predictor of healthy or unhealthy eating, and did not moderate the relationship between intention and behaviour. Only a single measure of trait self-control was used in Study 1, and it was concluded that multiple measures could be used to assess the construct of self-regulatory capacity in future studies (Duckworth & Kern, 2011). Across the literature, self-regulatory capacity has been measured through a variety of different methods, which stem from varying conceptualisations of the construct (Diamond, 2013; Duckworth & Kern, 2011; Nigg, 2017). This raises an important theoretical and methodological question for researchers looking to test TST with additional or alternative measures of self-regulatory capacity; do the different conceptualisations of self-regulatory

capacity and assessment tools relate to eating behaviour in the same way? This question will be explored in the current chapter.

4.1.1 Conceptualisation of self-regulatory capacity. Definitions of self-regulatory capacity can roughly be divided into two levels of specificity. First, some definitions describe self-regulatory capacity in broad terms as a global ability to exert self-control (e.g., Baumeister, Heatherton, & Tice, 1994). The capacity to exert self-control may be necessary to help individuals avoid temptations (e.g., a cookie on the kitchen counter), override prepotent responses (e.g., the habit of eating cookies) and to achieve or consistently work towards a achieving long-term, higher-order goal, such as eating healthfully or losing weight (Baumeister, Vohs, & Tice, 2007; Kotabe & Hofmann, 2015; Milyavkaya, Berkman, & de Ridder, 2019; Strack & Deutsch, 2004). Cross-sectional research suggests that people who show higher self-control by waiting for delayed rewards, also report eating a healthier diet (e.g., Daugherty & Brase, 2010; Garza, Ding, Owensby, & Zizza, 2016; Muñoz Torrecillas, Cruz Rambaud, & Takahashi, 2018). Furthermore, in a longitudinal survey, Keller et al., (2016) found that participants who had higher trait self-control at baseline showed greater improvements in diet quality after four years than those with lower self-control. Other research studies have, however, failed to find a significant relationship between measures of general self-control and food intake (e.g., Lumley, Stevenson, Oaten, Mahmut, & Yeomans, 2016; Wang et al., 2015). The variability in findings suggests that further research is needed to clarify the relationship between self-regulatory capacity conceptualised as self-control on a broad, trait, level and eating behaviour.

Secondly other researchers have conceptualised self-regulatory capacity as specific cognitive abilities that enable the top-down (as opposed to bottom-up, stimulus/impulse driven) control of behaviour; these are called executive functions, (Friedman & Miyake, 2017; Miyake et al., 2000). There is no agreement over how many separable executive

functions exist or how they should be categorised (Baggatta & Alexander, 2016). One categorisation, which has been widely used is Miyake et al.'s (2000) three dimensions of executive functioning; (i) inhibition; an individual's ability to deliberately stop or withhold a response, particularly when faced with a stimuli that is tempting to approach, (ii) working memory (updating); an individual's ability to actively hold information in their mind, which makes it possible for them to quickly retrieve, update, and manipulate this information, as well as shield it from interference, and (iii) shifting (mental flexibility); an individual's ability to switch back and forth between different tasks, mental sets, or styles of thinking.

These dimensions of executive function may help to explain the extent to which an individual is able to regulate the amount of unhealthy snacks that they consume. Effective inhibition may be necessary to stop an individual's desired (i.e., what they would like to do in the moment) or habitual response that is at odds with their long-term goals. For example, if a cookie is left on the kitchen counter, then an individual who is particularly fond of cookies or has a habit of eating cookies, but has a goal to eat healthfully, would need to resist their temptation or disrupt their usual habit, because even though it would be tasty and easy to eat the cookie, it would not support their healthful eating goal (Hofmann, Schmeichel, & Baddeley, 2012). A number of studies have reported that that individual differences in inhibitory control are related to various healthy and unhealthy eating behaviours, including the consumption of breakfast (Booker & Mullan, 2013), F&V (Booker & Mullan, 2013; Limbers & Young, 2015), saturated fat (e.g. Allom & Mullan, 2014; Hall, 2012; Limbers & Young, 2015), and energy dense snacks (Allan et al., 2010; Haynes, Kemps, & Moffitt, 2016; Houben & Jansen, 2014). Other studies, however, have failed to find a significant relationship between inhibition and healthful food consumption (e.g., Allom & Mullan, 2015; Collins & Mullan, 2011; Hall et al., 2008; Haynes et al., 2015; Wang et al., 2016; Wong &

Mullan, 2009). Further investigation into the relationship between inhibition and eating behaviour is needed to explain these inconsistent findings.

The second dimension of executive functioning – working memory – may be necessary to enable an individual to remember their long-term goals and plans (i.e., how to act in order for the goal to be achieved; Higgs, 2016; Kane & Engle, 2003; Martin, Davidson, & McCrory, 2018), such as, the goal to eat healthily and the plan to snack on an apple. Furthermore, working memory can direct attention, in a top-down manner, towards goal-relevant stimuli and away from stimuli that cause distraction or temptation, such as towards an apple and away from a cookie lying on the kitchen counter (Knudsen, 2007). Working memory may also aid in emotional regulation and cognitive reappraisal of cravings, thereby helping an individual to cope with aversive mental states without turning to food (Higgs & Spetter, 2018; Houben, Dassen & Jansen, 2016). These ideas suggest that working memory capacity is likely to be important in the control of eating behaviour. However, both correlational and prospective research to date has not found a consistent association between working memory and the consumption of either healthy or unhealthy foods (e.g. Allom & Mullan, 2014; Hofmann, et al., 2009; Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010; Stautz, Pechey, Couturier, Deary, & Marteau, 2016).

Finally, the process of shifting may be important to help an individual to switch between different ways of achieving the same goal in a changing environment ('means-shifting', Hofmann, Schmeichel, & Baddeley, 2012). For example, if the choice is no longer between a cookie and an apple, but between a cookie and an orange, then an individual who intends to select an apple when they desire a snack would need to be open to alternatives to enable them to choose the option that would help them achieve their goal to eat healthily (i.e., take the orange). Means shifting also allows individuals to abandon a sub-optimal means of achieving their goal in favour of testing and adopting a better method, such as creating a 1000

calorie deficit through diet and exercise rather than purely diet, which may be unachievable and unsustainable (Dohle, Diel, & Hofmann, 2018). Shifting also includes the ability to balance multiple goals, such as the goal to eat healthily and goal to enjoy eating ('goal-shifting', Hofmann, Schmeichel, & Baddeley, 2012). For example, research found that people who had been advised to be flexible and include 'treat/ cheat days' (on which they eat unhealthy foods) into their diet reported being more motivated to follow a calorie controlled diet than those who had been told to consistently diet across all situations (Coelho do Vale, Pieters & Zeelenberg, 2016). This is in line with the findings of a qualitative study investigating the practices of people who have successfully lost weight and maintained their lower weight (Joki, Mäkelä, & Fogelholm, 2017); flexibility to deviate from usual routines of healthy or calorie controlled eating was reported as a way to sustain healthy dietary practices in the long-run. It appears that flexibility can help people to accommodate 'treats' and adjust subsequent behaviour in line with the intended goal. However, as noted by Dohle et al. (2018), the relationship between shifting and eating behaviour is under researched in normal weight populations and further research is required.

4.1.2 Measurement of constructs. The inconsistent findings on the relationship between (dimensions of) self-regulatory capacity and eating behaviour may be explained by differences in how the constructs are measured in empirical studies (Duckworth & Kern, 2011). Measures of self-regulatory capacity can be divided is into subjective (typically self-report) and objective/task measures. Self-report questionnaires capture participants' beliefs about their thoughts and behaviours whereas objective methods measure behavioural outputs such as reaction time, typically through standardised tasks administered in controlled laboratory settings. The extent to which different measures capture the same construct and, importantly, are related to health behaviours has been questioned (Allom, Panetta, Mullan, & Hagger, 2016; Duckworth & Kern, 2011). It is necessary, therefore, to determine the

convergent validity between multiple measures of self-regulatory capacity, which should be theoretically related (e.g., all measures of general self-control) or show some diversity (e.g., across measures of different dimensions of executive functioning) and their relationship to eating behaviour.

Self-report questionnaires, such as the Self-Control Schedule (Rosenbaum, 1980), Self-Control Scale (Tangney et al., 2004) and the Habitual Self-Control Scale (Schroder, Ollis, & Davies, 2013) measure self-control at a broad trait level (Toplak, West, & Stanovich, 2013). Participants are asked about their typical behaviour or behaviour over a number of weeks/months/years (e.g., "Sometimes I can't stop myself from doing something, even if I know it is wrong", Tangney et al., 2004). Scores on these scales are assumed to reflect relatively stable individual differences in people's capacity to exert self-control (Vainik, Dagher, Dubé, & Fellows, 2013). In a meta-analysis, Duckworth and Kern (2011) found that the average correlation between self-report scales reflecting general self-control was $r_+ = .50$ ($k = 47$), which suggests that there is some degree of similarity in the construct assessed by these different scales; examples of scales included in the review are the Self-Control Scale (Tangney et al., 2004) as well as Eysenck I_7 Impulsiveness Scale (Eysenck, Pearson, Easting, & Allsopp, 1985) and the Barratt Impulsiveness Scale version II (Patton, Stanford, & Barratt, 1995). Furthermore, de Ridder et al. (2012) found that self-report measures of self-control show a small to medium positive correlation ($r_+ = .26$, $k = 50$) with a range of behaviours (e.g., school or work performance, sexual behaviour, and pro-social behaviour), and that, specifically, the Self-Control Scale (Tangney et al., 2004) showed a small correlation ($r_+ = .17$, $k = 14$) with eating and weight related behaviours (there was not enough data to calculate the effect size for other measures of self-control).

Self-report measures of specific executive functions are also available. The Behavioural Rating Inventory of Executive Functioning – Adult Version (Roth, Isquith, &

Gioia, 2005) asks participants to rate their ability to perform tasks in everyday life; participants rate the frequency with which they experience a series of thoughts or behaviours that indicate an impairment of the executive system. The Behavioural Rating Inventory of Executive Functioning – Adult Version comprises of nine subscales to index different dimensions of self-regulation; inhibit, shift, self-monitor, emotional-control, initiate, plan/organize, working memory, organization of materials, and task-monitor. To date there has been limited research reporting the correlation between scores on the Behavioural Rating Inventory of Executive Functioning – Adult Version and health behaviour. Two studies published in peer-reviewed journals found that lower impairment on the Behavioural Rating Inventory of Executive Functioning – Adult Version (overall score) and the subscales of inhibition, working memory, and shifting was related to more a healthful dietary pattern and F&V consumption in university students (Marshall & Elliot, 2016; Limbers & Young, 2015). Moreover, participants with lower impairment in inhibition and working memory reported eating less saturated fat (Limbers & Young, 2015). Desousky (2013; unpublished thesis), however, did not find a significant correlation between the three subscales of the Behavioural Rating Inventory of Executive Functioning – Adult Version mentioned above and F&V consumption in a similar sample of university students.

An objective method to measure general self-control is through delay of gratification tasks with real rewards. In these tasks participants are typically presented with a small reward (e.g., money) which they can have immediately, or a larger reward, which they must wait to receive; the difference in magnitude of, and time between, the two rewards can be changed over a number of trials to assess the extent to which the participants can wait to receive a larger reward and thus exhibit more self-control (Madden, Begotka, Raiff, & Kastern, 2003). Evidence from systematic reviews and meta-analyses suggests that inability to delay gratification is related to higher body mass index (BMI), although a clear relationship to food

intake has yet to be established (Amlung Petker, Jackson, Balodis, & MacKillop, 2016; Barlow Reeves, McKee, Galea, & Stuckler 2016; McClelland et al., 2016). Most studies in these reviews, however, use hypothetical rather than real choice tasks, since it would be financially and logistically difficult to provide meaningful rewards (e.g., £100) and delays (e.g., 1 year) across a number of choices. A feasible and meaningful single-choice monetary delay of gratification task with a *real* reward ($7 now vs $10 in one week) has been developed for use with adolescents and university students, but this has yet to be tested in relation to the outcome of food consumption (Isen, Sparks, & Iacono, 2014; Wulfert, Block, Santa Ana, Rodriguez, & Colsman, 2002). Initial evidence suggests that the ability to delay gratification on this task is associated with lower levels of impulsive behaviour (e.g., misconduct or substance use; Anokhin, Golosheykin, Grant, & Heath, 2011; Sparks, Isen, & Iacono, 2014) and may therefore be inversely related to the consumption of unhealthy snacks, which can be considered an impulsive behaviour (Churchill, Jessop, & Sparks, 2008).

Objective measures of specific executive functions have also been developed and often take the form of laboratory based behavioural measures administered by an experimenter or computer program in accordance with a standardised procedure. As such, the procedures are designed to capture the participant's capacity in that moment. Each task is designed to assess a single or limited range of executive functions, for example the stop-signal task (Logan et al., 1997), computation span task (OSPAN; Foster et al., 2015) and Switching, Inhibition and Flexibility Task (FitzGibbon, Cragg, & Carroll, 2014) are intended to measure inhibition, working memory, and shifting respectively (Vainik et al., 2013). The convergence between different behavioural measures of executive functioning is low, which suggests that they share some commonality but may, as intended, assess different dimensions of self-regulatory capacity ($k = 147$, $r_+ = .15$, $p < .001$, Duckworth & Kern, 2011; Friedman & Miyake, 2017). However, scores on different objective measures of the same dimension of

executive functioning often do not correlate highly and the relationship between self-regulatory capacity and eating behaviour differs between objective measures of the same dimension (Karr et al., 2018; Vainik et al., 2013). For example, some studies using the Stop-Signal Task have found a significant medium-sized correlation between inhibition and unhealthy snack consumption ($r = .28$, $p < .05$; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009) or high saturated fat intake ($r = .27$, $p < .05$; Allom & Mullan, 2014), while other studies have found small-sized correlations, which did not reach statistical significance ($r = 0.06$, $p > .05$; Hofmann et al., 2009; $r = 0.05$, $p > .05$; Lowe, Hall, Vincent, & Luu, 2014).

4.1.3 Measurement of food consumption. Food consumption can also be measured via self-report and objective tools. Typical self-report measures of food intake include food frequency questionnaires (e.g., Block rapid food screener; Block, Gillespie, Rosenbaum, & Jenson, 2000), keeping a food diary (e.g., Stautz et al., 2016), and a single question about past consumption (e.g., Pfeiler & Egloff, 2018). The most common objective measure of food consumption is a bogus taste test in which participants are given a sample of food to eat in a laboratory setting under the guise that their task is to evaluate it; however, unbeknown to the participant, the researcher is interested in the quantity of food eaten and weighs the food before and after the 'tasting' session (e.g., Fries & Hofmann, 2009).

Podsakoff, MacKenzie, Lee, and Podsakoff (2003) suggest that commonality in the method used to measure two variables may influence the observed correlation between them (common method variance). Systematic error in measurement may arises due to differences in the characteristics of the tasks (e.g,. answering questions about past food consumption on a Likert scale versus physically eating food in a research laboratory setting) or the greater possibility for self-report bias (e.g., the social desirability effect; Crowne & Marlowe, 1964) during subjective assessments; this may provide an explanation for the observed relationship

between the independent and dependent variables (Podsakoff et al., 2003). Since congruent measures (e.g., self-report of self-regulatory capacity and self-reported food consumption) share common method variance, it could be suggested that there would be a stronger relationship between variables measured this way than by incongruent measures. Most studies typically use a single type of measure of self-regulatory capacity and eating behaviour, which makes it difficult to directly compare the effect of type of measurement on the relationship between the variables. Research including multiples types of measures could better address this question.

4.1.4 The present research. On the basis of existing research it is difficult to estimate the extent to which self-regulatory capacity is related to eating behaviour because studies differ in their conceptualisation of self-regulatory capacity (measuring, for example, general self-control or specific executive functions) and the methods used to measure self-regulatory capacity and food consumption (cf. the distinction between self-report and objective/behavioural assessments). If the strength of the relationship between self-regulatory capacity and food consumption is related to conceptual and/or methodological factors then this may help to explain inconsistent research findings in this area and thereby expand our understanding of the relationship between self-regulatory capacity and unhealthy eating, underpin effective interventions to promote healthy eating behaviours, and consequentially improve population health.

There is some previous research that has sought to determine if self-report and behavioural measures of self-regulatory capacity show similar correlations to other health behaviours and health outcomes. For example, Allom, Panetta, et al., (2016) compared the correlation between self-reported physical activity with three self-report measures (Brief Self-Control Scale, Tangney et al., 2004; Self-Regulation Questionnaire, Brown, Miller, & Lawendowski, 1999; self-discipline facet of conscientiousness on the Revised NEO

Personality Inventory, Costa & McCrae, 1995) and three behavioural measures (Stop-Signal Task, Verbruggen & Logan, 2008; Stroop task, MacLeod & MacDonald, 2000; Iowa gambling task, Bechara, Damasio, Damasio, & Anderson, 1994) of self-regulatory capacity. They found that the self-report measures of self-regulatory capacity were significantly correlated to physical activity (.162, .163 and .177, respectively, all $p < .05$) whereas the behavioural measures were not (.004, -.058, .021, respectively, all $p > .05$). However, no clear conclusions can be drawn from the study as it confounded the measurement method with conceptualisation of self-regulatory capacity; the three self-report measures all assessed general self-control, whereas the behavioural measures assessed executive functioning. A more recent study by Dassen, Houben, Allom, and Jansen (2018) investigated whether participants' scores on both self-report (Behavioural Rating Inventory of Executive Functioning – Adult Version subscales of inhibit, working memory and shift, Roth et al., 2005) and behavioural measures of executive functioning (Stop-Signal Task, Logan, et al., 1997; 2-back task, Boselie, Vancleef, & Peters, 2016; trail making task, Reitan, 1992) predicted change in BMI following a weight loss program. After controlling for age and gender, objective working memory was a significant predictor of change in BMI, and in the regression model testing self-reported executive functions, inhibition added significantly to the model (Dassen et al., 2018); participants with higher objectively measured working memory or who reported fewer impairments in inhibition experienced greater weight loss. The researchers also included a measure of delay discounting but did not balance this with a self-report measure of general self-control such as the Brief Self-Control Scale.

The present study therefore investigated whether the conceptualisation of self-regulatory capacity and the method of assessment influences its relationship to eating behaviour by measuring, (i) global self-control using (a) self-report and (b) behavioural measures, and (ii) specific executive functions through (a) self-report and (b) behavioural measures. The

specific measures used in the present study are reported in Table 4.1. The study also extended previous research by using both an objective and subjective measure of chocolate consumption; a taste test and self-report question, respectively. Chocolate consumption was chosen as it exemplifies a common self-regulation dilemma (i.e., to eat or not to eat an unhealthy snack) and is widely consumed as a snack in the UK.

Table 4.1.

Measures of self-regulatory capacity and eating behaviour used in Study 2

	Construct		
	General Self-Control	Dimensions of executive function	Eating behaviour
Self-report	Brief Self Control Scale (Tangney et al., 2004)	Behavioural Rating Inventory of Executive Functioning – Adult Version (Roth et al., 2005): - Inhibit - Working memory - Shifting	- Reported percentage of chocolate consumed during the taste test - Past behaviour (chocolate consumption)
Objective	Delay of gratification task (single cash choice; Wulfert et al., 2002)	- Stop Signal Task (inhibition; Logan et al., 1997) - Computation span (working memory; Foster et al., 2014) - Switching, Inhibition and Flexibility Task (shifting; FitzGibbon et al., 2014)	Calories consumed during "chocolate taste test"

Based on the principle of common method variance (Podsakoff et al., 2003) it was hypothesised that self-report measures of self-regulatory capacity would be more highly related to self-reported chocolate consumption than to objectively measured chocolate button consumption, whereas objective measures of self-regulatory capacity would be more highly related to objective than self-reported food intake. Due to inconsistent research findings, no hypotheses were made regarding the strength of the association between general measures of self-control or specific measures of executive function and eating behaviour.

Based on the principle of common construct measurement (Podsakoff et al., 2003) and past research (e.g. Allom, Panetta, et al., 2016; Duckworth & Kern, 2011; Vainik et al., 2013) it was predicted that the measures of general self-control would be significantly correlated with each other, but the measures of specific dimensions of executive functions would shower weaker inter-correlations as the tasks that assess executive functioning have more varied demands.

4.2. Method

4.2.1 Participants. Participants were recruited by three methods. First, undergraduate psychology students were recruited from the Psychology Department's online research participation scheme. In exchange for participation, students received course credits plus entry into a prize draw for the chance to win one of two £50 gift vouchers. Second, students who had not opted out of a 'volunteers' list at the University were sent an email with details of the study including a link to a sign-up form. Third, these same details were also posted on a University run 'volunteers' webpage for students interested in taking part in research studies. Participants who were recruited via the second and third methods received a £10 gift voucher in exchange for participation. In all cases, participation was voluntary and participants were screened to ensure that they had no allergies or preferences which meant that they could not eat the chocolate buttons during the taste test.

The final sample included 118 university students (69.5% female; 68.6% undergraduates, 13.6% Masters students and 17.8% PhD students) aged between 18 and 53 years (age *M* = 22.23, *SD* = 6.01). The majority of the participants lived in the UK (63.6%; 60.2% White or White British, 20.3% Asian or British Asian, 4.2% Black or Black British) and reported that they were not restricting their food intake or on a diet (92.6%). The mean BMI of the sample was 22.23 (*SD* = 6.01).

An a prior power analysis could not be conducted because it was unclear from the literature what effect size would be expected for the relationship between self-control and food intake. Post-hoc power analyses revealed that the sample size of 118 would be sufficient to detect a small-to-medium effect of *r* = .25 with 80% power and alpha set at 0.05 (Faul, Erdfelder, Lang, & Buchner, 2007).

4.2.2 Procedure. Participants attended a 1 hour laboratory session, ostensibly about personality and taste perception (cf. Friese & Hofmann, 2009). This cover story was chosen to encourage participants to eat at least some of the chocolate buttons during the taste test and to reduce demand characteristics that may have arisen if participants suspected that that their food intake was being measured (Robinson, Kersbergen, Brunstrom, & Field, 2014; Thomas, Dourish, & Higgs, 2015). Participants were asked to have nothing to eat or drink (except for water) for 2 hours before the experiment to equalise the level of hunger across participants (e.g., Haynes et al., 2016). On arrival at the laboratory, each participant was informed by the researcher that they would be taking part in a number of different tasks and questionnaires on the computer, after which they would be asked to rate two kinds of chocolate buttons in terms of different qualities. The experimenter then left the room and the participant completed the informed consent form. In order not to alert participants to the purpose of the experiment and to support the cover story, the measures of demographics, hunger, past behaviour, and intentions were embedded in a short filler questionnaire including questions about their

personality. Next, the participant completed two self-report scales to measure self-regulatory capacity (i.e., Brief Self-Control Scale and Behavioural Rating Inventory of Executive Functioning – Adult Version). The order of presentation was counterbalanced across participants.

Once all of the questions had been answered, the participant informed the experimenter who was sat outside the testing room in the corridor or in a small room next door. The experimenter then set up the first of the computer tasks to measure executive functioning (i.e., OSPAN, Switching, Inhibition and Flexibility Task, or Stop-Signal Task) and reminded the participant that if they were unsure of the instructions then they could ask for clarification. The experimenter then left the room until the participant indicated that they had finished the task, at which point the experimenter then set up the next task on the computer. This procedure was repeated for all three computer tasks to measure executive functioning, which were presented in a counterbalanced order.

When the participant had completed the final computer task to measure executive functioning, the experimenter explained the taste test in which the participant would be asked to sample two kinds of chocolate buttons and to complete a questionnaire rating each on a number of dimensions. The experimenter then presented the participant with two plates, one containing 50g of milk chocolate buttons and the other containing 50g of white chocolate buttons. Participants were told that they could eat as much or as little of the chocolate as they wanted, but that they must try some in order to be able to answer the questions about taste perception (Houben & Jansen, 2014). The experimenter also made it clear to the participant that they would have five minutes to complete this task and that if they had finished their ratings before this time then they should stay seated in the testing room and wait for the experimenter to return.

The participant was left alone for five minutes to complete the taste test, after which the experimenter returned to remove the chocolate buttons. The experimenter then left the room, while the participant reported the proportion of chocolate buttons that they thought they had consumed during the taste test.

Finally, the experimenter told the participant that the main part of the experiment was over and asked them to help in another short task where they would make a decision about money (the delay of gratification task). Participants who were recruited via method one were led to believe that they could keep the amount of money that they chose, while participants recruited via the other two methods were told to imagine that they could keep the money that they chose[6]. If the participant agreed to take part (all but one participant agreed) they were asked to choose between receiving £7 immediately or £10 in one weeks' time. The experimenter showed the participant both amounts of money in cash, as well as an envelope and pen, then explained that if the participant chose the second option they could write their address on the envelope and the money would be posted to them a week later. Once the participants recruited via the first method had made their choice the experimenter revealed that they would not receive the money. Instead, participants were offered the chance to enter a prize draw for 2 x £50 Amazon vouchers and assured that they would receive the course credit that was stated in the advertisement for the study. All participants were thanked for their time, given a verbal debrief and asked not to tell other students about what had happened during the study.

Ethical approval for this study was granted by the university ethics committee

[6] The pattern of correlations between delay of gratification and food consumption outcome measures was the same for the participants who thought that the monetary choice was real, hypothetical and both groups analysed together Independent samples t-tests showed that there was no difference in any of the measures of self-control/executive functioning and eating behaviour between groups. Therefore, the data was analysed as a single group.

4.2.3 Measures

Demographics. Participants reported their age, gender, height, weight, nationality, and ethnicity. Participants also reported if they were currently on a diet or restricting their food intake.

***Hunger*.** Participants reported their current level of hunger at the beginning of the experiment in response to a single item rated 1 (*not hungry at all*) to 7 (*extremely hungry*) (Haynes et al., 2016).

***Intentions*.** Intentions to avoid high calorie snacks were measured by two items taken from Allan et al. (2010); "I intend to avoid high calorie snacks between meals" and "I want to avoid high calorie snacks between meals" (4-point scale from '*strongly agree*' to '*strongly disagree*', $\alpha = .80$).

***Personality*.** To support the cover story, participants were asked to complete the Ten-Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 2003), which uses two items to assess each personality dimension of the "Big Five" (i.e., extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience). Participants responded on a 7 point Likert scale (1 = *Strongly disagree* to 7 = *Strongly agree*) to the stem 'Please indicate the extent to which you agree or disagree with the following statements. I see myself as: … '.

Self-report measures of self-regulatory capacity.

General self-control. The 13-item Brief Self-Control Scale (Tangney et al., 2004) was used as a self-report measure of general self-control. Participants were asked to rate from 1 (*not at all*) to 5 (*very much*) the extent to which the statements reflect their typical behaviour, for example "I am good at resisting temptations" or "I wish I had more self-discipline" (reverse coded). The Brief Self-Control Scale was chosen because it has been widely applied,

shows good psychometric properties and has been shown to correlate with eating behaviour (e.g., de Ridder et al., 2012; Vainik et al., 2013).

Executive functioning. Participants completed three subscales of the Behavioural Rating Inventory of Executive Functioning – Adult Version (Roth et al., 2005), which map onto the three dimensions of executive functioning proposed by Miyake et al. (2000); i.e., inhibition, updating/working memory, and shifting. The 8-item inhibit scale measured inhibitory control and the ability to resist temptations (e.g., "I am impulsive", α = .69). The 8-item working memory scale measured the ability to actively attend to information and hold it in their one's while completing a task (e.g., "remembering things, even for a few minutes", α = .81). The 6-item shift scale measured the ability to flexibly switch both behaviourally and cognitively when the situation requires (e.g., "thinking of different ways to solve a problem when stuck", α = .62). Participants responded on a three point scale, of 1 = *never*, 2 = *sometimes*, 3 = *often*. A raw score for each participant was created by totalling their score to the individual items per scale. This was then converted into a t-score using the normative conversion tables in the Behavioural Rating Inventory of Executive Functioning – Adult Version Professional Manual (Roth et al., 2005). The scores were reversed so that high scored indicated better performance (i.e., greater self-control) on inhibition, working memory, and shifting. There were a lack of self-report measures of executive functioning to choose from, and the Behavioural Rating Inventory of Executive Functioning – Adult Version was chosen because it has been standardised and validated for use with adults aged 18-90 years from a range of backgrounds and shows good reliability in healthy samples (Roth et al., 2005).

Objective measures of self-regulatory capacity.

General self-control. Participants completed a single choice delay discounting task. They were given the choice of receiving £7 in cash immediately or £10 in cash one week

later. In testing, Wulfert et al. (2002) established that no preference was shown for either reward with the time interval fixed at one week if the value of the immediate reward was 70% that of the delayed reward. Participants who chose the immediate option were coded 0, while those who chose the delayed option were coded 1.

Executive functioning. All three of the objective executive function tasks were completed on a computer with a 17-inch monitor and running E-Prime 2.0 software (Psychology Software Tools, Inc., Pittsburgh, PA). Participants were sat approximately 80 cm from the screen and took around 10 minutes to complete each task.

Inhibition was measured by the *stop-signal task* (Logan et al., 1997). This procedure is commonly used in literature to examine the association between self-control and eating behaviour (e.g., Guerrieri et al., 2007; Haynes et al., 2015; Houben & Jansen 2011; Jansen et al., 2009; Nederkoorn et al., 2009). Participants were asked to make a choice between two stimuli unless a stop-signal was presented, in which case they had to withhold their response. Participants completed one block of 32 practice trials, followed by 3 blocks of 64 experimental trials (Allom & Mullan, 2014). Each trial began with a fixation cross ('+') presented in the centre of the screen for 500ms, followed by an 'X' or 'O' presented for 1000ms then a blank screen for 1000ms. Participants were asked to press the '/' key if an X appeared and the 'z' key if an O appeared unless they heard a tone. The tone was presented as a stop signal on 25% of trials ('stop' trials), counterbalanced across the stimuli. The tone was initially presented 250ms after the stimulus and the delay increased by 50ms to make the task harder if participants successfully inhibited their response on the previous trial. In the original Stop-Signal Task (Logan et al., 1997), the time between the stimulus and the tone decreased to make the task easier if participants were unsuccessful at inhibiting their response on a previous trial. Due to a computer programming error, this did not happen in the current study.

This meant that the data for this task was not a meaningful measure of self-regulatory capacity and therefore could not be analysed.

Working memory was measured by the *shortened operation span task* by Foster et al. (2015). Participants were required to hold letters in memory (e.g., K) while completing a distracter task of solving simple maths problems (e.g., (2 x 2) – 1 = ?). Before the experimental trials began the participants practiced the letter recall (4 trials), maths problems (15 trials) and whole procedure (3 trials) with ongoing feedback on whether their responses were correct. There were 15 experimental trials with three to seven simple maths problems, each followed by the presentation of a letter to hold in memory. Participants input their response to the maths question (e.g., 3) using the keyboard. Once all of the stimuli were presented participants were asked to recall the letters in order. Participants then received feedback on the number of letters and maths problems that they had answered correctly and the percentage of correct answers across all trials to that point. Participants were asked to try and keep their total percentage correct over 85% to ensure that they were engaging with both the letter recall and maths problems. The number of letters recalled in the correct order (known as the 'partial score'), was calculated as a measure of working memory. This shortened version of the standard operation span task has been shown to be reliable and valid when compared with measures of general intelligence and longer versions of the task from which it is derived (Foster et al., 2015; Redrick et al., 2012; Vainik et al. 2013).

Shifting was measured by the *Switching, Inhibition and Flexibility Task* (FitzGibbon et al., 2014). During the task, participants were asked to classify a novel shape according to one of two dimensions: shape or colour. On each trial, participants viewed a classification rule (i.e., 'shape' or 'colour') for 700 msec before being presented with a shape stimulus in the top middle section of the screen. After 500 msec, the stimulus remained on screen and two additional shapes were presented on the bottom left and bottom right of the screen. One

shape matched the stimulus on colour and the other matched the stimulus on shape – neither matched the stimulus on both dimensions. Participants were required to choose which shape matched the stimulus according to the rule and to press the 'a' key to select the shape on the left and the 'l' key to select the shape on the right. The rule changed throughout the trials. Participants completed one block of 10 practice trials with feedback, followed by two blocks of 16 trials with a single rule (the order of the 'shape' rule and 'colour' rule as the first block was counter balanced across participants). Participants then completed three blocks of 49 experimental trials in which the order of the rules was pseudo-randomised so that the participant had to apply the same rule as the previous trail on 50% of occasions (*non-switch* trials e.g. 'shape' then 'shape') and have to *switch* to the alternative rule on 50% of occasions (e.g. 'shape' then 'colour'). Data from the first trial of each experimental block was excluded from analysis as it did not represent a switch or a non-switch trial. Any trials with a reaction time under 200 milliseconds and over 10,000 milliseconds were also removed from analyses, next, any trials that were outside of ±2.5 SD from the individual's mean for each type of trial or a not correct trial that followed a correct trial were excluded in the analyses. The mean reaction times for non-switch and switch trials were calculated from trials that met the selection criteria. The switch cost for reaction time (reaction time on non-switch trials minus switch trials; FitzGibbon et al., 2014) served as a measure of switching, with higher scores indicating greater self-regulatory capacity in this dimension of executive functioning. The Switching, Inhibition and Flexibility Task was chosen over other measures of shifting because it has been designed to have lower incidental demands than other computer tasks that measure shifting (FitzGibbon et al., 2014).

Chocolate consumption.

Self-reported past behaviour was measured in the battery of questions at the start of the study. Chocolate consumption was objectively measured via what was described to

participants as a taste test, followed by a subjective assessment of the amount of chocolate consumed during the taste test.

Past behaviour: Self-reported past behaviour was measured with two items adapted from Allom, Panetta, et al. (2016); "In the past week, how often have you eaten chocolate?" rated on a Likert scale from 1 (*a few times*) to 5 (*every day*) and "In the past week, I have eaten chocolate" (1 = *never* to 5 = *most days*).

Taste test. In the taste test, participants were presented with 50g of milk chocolate buttons and 50g of white chocolate buttons. Participants were left alone in a laboratory room with no windows for 5 minutes to rate the chocolate buttons on six dimensions (e.g., including taste, texture, and sweetness) and compare the similarity between the milk and white variety (Hofmann et al., 2009). Furthermore, participants did not see the packages for the chocolate buttons and were not given any information on the macronutrient content. This procedure was intended to reduce the influence of social and nutritional concerns on food intake (Higgs & Thomas, 2016). The weight of the chocolate buttons was weighed to the nearest 0.1g before and after the tasting session. The proportion of chocolate consumed in grams was determined by subtracting the weight of the remaining chocolate from the initial weight. Total food intake in calories was calculated by multiplying the amount of grams eaten by number of calories per gram for each type of chocolate and then totalling the amounts.

Self-reported intake: Once the chocolate buttons had been removed from sight, participants used a visual analogue scale (0 to 100) to indicate the proportion of the chocolate buttons that they thought that they consumed in the taste test.

4.2.3 Analyses. Partial correlations, controlling for hunger, were computed to examine the relationship between measures of self-regulatory capacity and chocolate consumption. Further post-hoc analyses were run to examine the relationship between these

variables for participants with low (scores of 1 or 2, which fell below the median of 2.5) and high (scores of 3+) intentions avoid eating chocolate. It was assumed that the taste test would provide a greater self-regulation dilemma for those with high intentions to avoid chocolate.

The data for participants who scored 3 *SD* above or below the mean on individual tasks or scales were removed for that variable. This accounted for less than 3% of the data for the Switching, Inhibition and Flexibility Task, OSPAN, and chocolate button consumption tasks. There were no outliers on the self-report scales. Cases were excluded pairwise in the correlation analyses.

4.3 Results

4.3.1 Correlations between self-control, executive functioning, and food consumption.

None of the measures of self-control or executive functioning were significantly correlated with the objective or subjective amount of chocolate buttons consumed during the taste test, or reported chocolate consumption frequency in the past week (see Table 4.2).

4.3.2 Correlations between measures of self-control and executive functioning.

The two measures of general self-control (Brief Self-Control Scale and delay of gratification task) were not significantly correlated with each other. The three subscales of the Behavioural Rating Inventory of Executive Functioning – Adult Version measuring (self-reported) dimensions of executive functioning were not significantly correlated with the objective measures of executive functioning; scores on the OSPAN (measuring working memory) or Switching, Inhibition and Flexibility Task (measuring switching) tasks.

The two self-report measures (Brief Self-Control Scale and Behavioural Rating Inventory of Executive Functioning – Adult Version) showed a significant positive correlation such that those with higher scores in general self-control reported better functioning in the dimensions of inhibition, working memory, and shifting. The objective

Table 4.2.

Means, Standard Deviations and Partial Correlations between measures of Self-Control and Unhealthy Food Intake

	2.	3.	4.	5.	6.	7.	8.	9.	10	*M*	*SD*
1. Brief Self-Control Scale	.305**	.509***	.561***	.087	-.081	.155	-.083	-.064	.076	4.40	.63
2. BRIEF- shift (t score)		.491***	.218*	.092	-.074	.036	-.034	-.134	-.049	57.04	9.81
3. BRIEF- WM (t score)			.496***	.096	.054	.181	-.142	-.078	.111	60.06	10.84
4. BRIEF- inhibit (t score)				.179	-.002	.173	-.083	-.066	-.019	55.39	9.72
5. Delay of Gratification					.072	.060	.059	-.117	.030	.75	.44
6. OSPAN (partial score)						-.046	-.086	.042	.074	60.07	10.90
7. SwIFT (switch cost RT)							-.001	-.057	-.070	22.62	61.05
8. Total Buttons (Cals)								.564***	.070	96.81	62.07
9. Total Buttons –Self Report									.062	27.26	19.85
10. Past Behaviour										2.71	1.27

*Note. * p < .05. ** p < .01. *** p < .001*

measure delay of gratification was not correlated to either the OSPAN or Switching, Inhibition and Flexibility Task.

Finally, scores on the three dimensions of the Behavioural Rating Inventory of Executive Functioning – Adult Version were positively correlated with each other, but performance on the OSPAN was not significantly correlated to performance on the Switching, Inhibition and Flexibility Task.

4.3.3 Inter-correlations between measures of chocolate consumption. Participants ate an average of 18% of the chocolate buttons during the taste test, with consumption ranging from 2% to 56% (*SD* = 12). The amount of buttons consumed was positively correlated with how much participants reported that they had eaten during the taste test. Reported chocolate consumption frequency during the past week (i.e., past behaviour) was not related to objective or reported chocolate button consumption during the lab session.

4.3.4 Low versus high intenders. Independent samples t-tests showed no significant differences between those who had high and low intentions to consume high calorie snacks on any of the self-regulatory capacity or chocolate consumption measures ($p > .05$). For participants with low intentions to avoid chocolate ($N = 38$), none of the measures of self-control or executive functions were correlated with either of the three outcome measures of chocolate intake (see Table 4.3). The pattern of correlations for participants with high intentions to avoid chocolate ($N = 57$) was similar to that of low intenders, except that performance on the Switching, Inhibition and Flexibility Task was positively correlated to self-reported consumption of chocolate in the past week ($r = .39$, $p < .001$); participants with greater flexibility reported consuming chocolate more frequently than those with lower, but still above average, scores on switching (see Table 4.4).

Table 4.3.

Means, Standard Deviations and Partial Correlations between measures of Self-Control and Chocolate Consumption for participants with low intentions (scores of 1 and 2)

	2.	3.	4.	5.	6.	7.	8.	9.	10.	*M*	*SD*
1. Brief Self-Control Scale	.058	.543**	.550**	-.042	-.229	.024	.027	-.138	.291	4.37	.59
2. BRIEF- shift (t score)		.356*	.021	.030	-.145	-.414*	-.088	-.303	.026	-56.47	11.03
3. BRIEF- WM (t score)			.274	-0.129	-.305	-.038	-.123	-.094	.153	-60.84	9.40
4. BRIEF- inhibit (t score)				.061	.152	-.118	.059	-.015	-.071	-56.34	9.23
5. Delay of Gratification					.141	-.027	.170	-.242	-.154	0.83	.38
6. OSPAN (partial score)						-.114	-.104	-.017	-.045	62.92	8.36
7. SwIFT (switch cost RT)							-.007	.094	.152	-22.44	51.59
8. Total Buttons (Cals)								.465**	-.112	102.53	71.44
9. Total Buttons –Self Report									-.167	29.50	21.46
10. Past Behaviour										2.96	1.48

*Note. * p < .05. ** p < .01. *** p < .001*

Table 4.4.

Means, Standard Deviations and Partial Correlations between measures of Self-Control and Chocolate Consumption for participants with high intentions (scores of 3+)

	2.	3.	4.	5.	6.	7.	8.	9.	10.	*M*	*SD*
1. Brief Self-Control Scale	.468***	.535***	.518***	.082	-.017	.212	-.236	-.053	-.013	4.46	.66
2. BRIEF- shift (t score)		.532***	.231*	-.040	-.203	.252	.074	.149	-.079	-56.85	9.15
3. BRIEF- WM (t score)			.674***	.175	.130	.134*	-.146	.002	.243	-59.09	11.32
4. BRIEF- inhibit (t score)				.150	-.084	.351*	-.150	-.055	.072	-54.81	9.453
5. Delay of Gratification					-.064	.065	.094	.033	.200	0.72	.45
6. OSPAN (partial score)						-.057	-.086	.103	.172	60.42	12.10
7. SwIFT (switch cost RT)							.001	-.072	.321*	-13.06	69.24
8. Total Buttons (Cals)								.605***	.167	94.63	61.15
9. Total Buttons –Self Report									.100	26.18	19.94
10. Past Behaviour										2.26	1.70

*Note. * p < .05. ** p < .01. *** p < .001*

4.4 Discussion

The present research investigated whether different conceptualisations and measures of self-regulatory capacity relate to eating behaviour in the same way. It extended previous research (e.g., Dassen et al., 2018; Limbers & Young, 2015) by using objective and self-report measures of both general self-control and specific executive functions; namely, inhibition, working memory, and shifting, within the same study. In addition, eating behaviour was measured through a self-report measure of past behaviour and measuring actual, and self-reported, consumption during a bogus taste test. It was found that none of the measures of self-regulatory capacity significantly correlated with any of the measures of chocolate consumption for the sample as a whole. This finding is in line with the results of several correlational studies. For example, Wang et al. (2015, 2016) found no association between scores on the Brief Self-Control Scale or the Stop-Signal Task and chocolate in an 8 minute taste test, similarly Hofmann et al. (2008, 2009), found no association between scores on the OSPAN and chocolate intake in a 5 minute taste test. Research has also reported non-significant correlations between the Brief Self-Control Scale (Junger & van Kampen, 2010), OSPAN (Allom & Mullan, 2014) and delay of gratification task (Lumley et al., 2016) with self-reported consumption of unhealthy foods high in saturated fat and/or sugar (similar to the properties of chocolate).

The present findings are unlikely to be the result of weak or invalid methods. The study had sufficient power to detect a small-to-medium sized correlation and the measures of self-regulatory capacity used were (as far as possible) established as reliable and valid in a similar target population (see sections 4.2.1 and 4.2.3). To the author's knowledge, the Switching, Inhibition and Flexibility Task has not been tested in an adult population, but the measure was developed to reduce incidental demands (e.g., language) present in other tests of the executive function of shifting/flexibility (FitzGibbon et al., 2014). The Switching,

Inhibition and Flexibility Task was chosen because it may offer a purer measurement of the construct of shifting than measures previously used in this research area (e.g., the Wisconsin Card Sorting Test; Nyhus & Barceló, 2009).

The lack of correlation between measures of self-regulatory capacity and eating in the sample overall may, in part, be explained by an assumption made during the study design process; that participants would experience a self-regulation dilemma when presented with chocolate and would need to draw on their self-regulatory capacity in order to limit their consumption (Milyavskaya et al., 2019). This may have been true for participants if they were on a diet or intending to avoid chocolate or to limit their consumption, but not for example, (i) if they had strong hedonistic goals to eat tasty food, which would make eating chocolate goal congruent, or (ii) if they did not particularly like the chocolate samples, which would make it easy for them to 'resist' it (Kotabe & Hofmann, 2015). In the present study, the sample as a whole only had average scores on the measure of intentions to avoid consuming chocolate, and therefore, further analyses were run with sub-groups of participants with low and high intentions to avoid eating chocolate.

The results showed that, for participants who had low intentions to avoid eating chocolate there were no significant correlations between the measures of self-regulatory capacity and eating behaviour. This finding supports theories which suggest that self-regulatory capacity is needed to help individuals to act on their intentions to reach their long-term goals, but is not required or relevant in situations where the individual does not hold an incongruent long-term goal (e.g., Kotabe & Hofmann, 2015). For participants with high intentions to avoid eating chocolate, however, there was one significant association between scores on the Switching, Inhibition and Flexibility Task (which assesses shifting) and past behaviour; specifically, participants who were less able to shift between goals reported that they had eaten chocolate less frequently in the previous week than those with better shifting

ability. This result suggests that people who are less flexible may be better able to rigidly follow their goal to avoid eating unhealthy snacks than those who show greater flexibility. This finding is contrary to the idea introduced in section 4.1.1 that flexibility can help people to shift between suboptimal means and goals to achieve successful self-regulation overall, and should therefore be associated with eating fewer unhealthy foods. It is important to note that the Switching, Inhibition and Flexibility Task measured only goal-shifting, which Hofmann, Schmeichel, and Baddeley (2012) argue is a type of flexibility that can be differentiated from means-shifting. The Behavioural Rating Inventory of Executive Functioning – Adult Version questionnaire measured both goal and means shifting (e.g., "I get disturbed by unexpected changes in my daily routine" and "I have trouble thinking of a different way to solve a problem when stuck", respectively; Roth et al., 2005). Scores on the Behavioural Rating Inventory of Executive Functioning – Adult Version were an aggregate of items measuring goals- and means-shifting, and were not found to be related to eating behaviour; future research could, therefore, explore if goal-shifting and means-shifting relate differently to chocolate consumption.

No other measures of self-regulatory capacity were significantly associated with eating behaviour in those who intended to avoid eating chocolate. It is possible that this lack of association may have occurred if participants in the study did not recognise the taste test as a self-regulation dilemma (since they were instructed to eat the chocolate) and therefore they did not draw on their capacity to self-regulate (Weathers & Siemens, 2018). Indeed, Van der Lann, de Ridder, Viergever, and Smeets (2014) found that participants who intended to eat healthily often failed to recognise self-regulation dilemmas during a lab-based food choice task. Another explanation may be that the motivation of participants to avoid eating chocolate may have been diminished in the research environment, especially if they saw it as a justification to eat chocolate (Kotabe & Hofmann, 2015; Milyavskaya et al., 2018; Taylor,

Webb & Sheeran, 2013). These explanations do not, however, account for the null finding for measures of participant's self-regulatory capacity and chocolate consumption during the past week in their typical living environment. One way forward would be to use exploratory momentary assessments to investigate the relationship between self-control and eating behaviour in a real world setting and account for real-time variability in self-regulatory capacity, intentions/ motivation, and temptations in the environment, which have been shown to influence snack consumption (Elliston, Ferguson & Schuz, 2017; Hofmann, Baumeister, Förster, & Vohs, 2012; Inauen, Shrout, Bolger, Stadler, & Scholz, 2016; Powell, McMinn, & Allan, 2017). It should be noted though, that given the present results, it is not clear which measures of self-regulatory capacity would be suitable to use in future exploratory momentary assessment research exploring the relationship between self-regulatory capacity and unhealthy eating behaviour. Since collecting and analysing data from multiple variables across time can be a complicated, expensive, and time-consuming process, it is necessary to have a clear idea of which measures are most suitable for use in such a study before research can progress in this area.

As well as investigating the relationship between self-regulatory capacity and unhealthy eating behaviour, the present study also aimed to examine the relationship between different measures of general self-control and dimensions of executive functioning (inhibition, working memory, and shifting). It was predicted that measures of general self-control (i.e., Brief Self-Control Scale and delay of gratification) would be related to each other and that measures of executive functions (i.e., Behavioural Rating Inventory of Executive Functioning – Adult Version, OSPAN, Switching, Inhibition and Flexibility Task) would show weaker inter-correlations, however, none of those proposed relationships were significant. Across the sample as a whole, it was found that the self-report measures (Brief Self-Control Scale and BRIEF- A inhibit, working memory and shift) were significantly

related to each other, whereas the objective measures (delay of gratification, OSPAN, and Switching, Inhibition and Flexibility Task) were not related to each other or to any of the self-report measures. Since there is a greater difference in the task demands of the objective than self-report measures, these findings lend support to Podsakoff et al.'s (2003) observation that common construct measurment may contribute to the correlation between variables found in research studies.

4.4.1 Limitations

Several caveats related to the characteristics of the participants and study design must be acknowledged. First, the sample was drawn from a healthy student population, which limits the generalisability. It is, however, the same population as recruited in Study 1 and, therefore, if the results had shown that certain measures of self-regulatory capacity were more strongly correlated with unhealthy eating behaviour, then the results could have informed future research to extend Study 1. Second, the whole sample scored on the higher end of the measures of self-regulatory capacity and consumed an average of 100 calories of chocolate buttons, which is ≤ 5% of the recommended daily calorie intake for weight maintenance in adults and would be considered a suitable portion size for a snack, even for children (Change 4 Life, 2018; NHS, 2019). Evidence suggests that those with high self-control are less tempted by a range of situations (Imhoff, Schmidt, & Gerstenberg, 2014) and experience less 'problematic desires' (Hofmann, Baumeister, et al., 2012) than those with low self-control; therefore, further research in a sample with more heterogenous scores on the measures of self-regulatory capacity would be useful. Third, the present study used a correlational design with data analysed at the group level which means that it cannot establish a cause-and-effect relationship between variables. Moreover, it does not, as discussed above, have high ecological validity to capture the impact of individual fluctuations in self-control on eating behaviour in daily life, which may be influenced by temptations and competing goals

(Hofmann, Baumeister, et al., 2012). Fourth, a single task was used for each of the combinations of 'self-regulatory capacity construct x measurement method' identified in Table 4.1. This may be an issue, especially for the objective measures of executive functioning, since the tasks have different lower level, non-executive processing demands (e.g., language; Miyake et al., 2000) than other tasks that could have been selected (e.g., the n-back task instead of the OSPAN), therefore, it would be premature to draw conclusions on the basis of a single task. Nęcka, Gruszka, Orzechowski, Nowak, & Wójcik (2018) suggested that using a battery of tests to measure the same construct and extracting latent variables could provide a clearer picture of the relationship between measures of self-regulatory capacity and the relationship of those measures to behaviour, although this would place a high burden on participants (Nęcka et al.'s study was 3 hours in duration) and still falls prey to the same criticism that different results would have been obtained if different tasks were used. A final limitation of the present study was that data from the objective measure of inhibition could not be analysed due to a computer programming error.

4.4.2 Conclusions

Theories propose that self-regulatory capacity is used to help individuals avoid the consumption of unhealthy food (e.g., Hall & Fong, 2007). However, research has failed to find a consistent and robust relationship between measures of self-regulatory capacity (i.e., self-control/executive functioning) and eating behaviour, which may be due to the multiple ways in which self-regulation has been defined and measured (Nigg, 2017). The present study found that scores on measures of general self-control and the executive functioning dimensions of inhibition, working memory, and shifting were not correlated with unhealthy eating behaviour. This was the case when the constructs were measured via self-report or via objective/behavioural measures. Only one dimension of executive functioning was significantly correlated with self-reported chocolate button consumption for participants with

high intentions to avoid chocolate, who, theoretically should have experienced a greater self-regulation dilemma when presented with the chocolate. Further research is needed to synthesise the current literature to establish the strength of the relationship between measures of self-regulatory capacity and (un)healthy eating, and to investigate the impact of conceptual, methodological, and demographic factors (e.g., intention strength) as moderators of the relationship.

Chapter 5. Is self-regulatory capacity associated with healthful eating? A systematic review and meta-analysis

5.1 Introduction

Given the burden of diet-related diseases there is an urgent need to develop interventions that effectively modify the amount of healthy and unhealthy foods eaten by individuals within the population and develop a more healthful eating pattern (i.e., eating a greater quantity of healthy foods and/or a smaller quantity of unhealthy foods). Temporal Self-regulation Theory (TST) suggests that one potential target for these interventions may be self-regulatory capacity, which refers to the underling cognitive processes and physiological energy that influence an individual's ability to regulate their behaviour, especially in accordance with long-term goals and interests (Hall & Fong, 2007).

Self-regulatory capacity has been conceptualised and measured in a number of different ways, including as self-control (i.e., the ability to pursue a long-term goal despite difficulties such as conflicting goals, desires, or unwanted impulses; Baumeister et al. 2007; Fujita, 2011; Kotabe & Hofmann, 2015), executive functioning, (i.e., the operation of higher order cognitive processes, such as inhibition, working memory, and shifting, that facilitate the top-down control of behaviour; Hall & Fong, 2015; Hofmann, Schmeichel, & Baddeley, 2012; Miyake et al., 2000) and the ability to delay immediate gratification in order to achieve a longer-term goal (Mischel, Shoda, & Rodriguez, 1989). Measures of these aspects of self-regulatory capacity were used in Study 2. In addition, Duckworth and Kern (2011) included measures of impulsiveness (i.e., poor control of impulses) in their meta-analysis of the convergent validity of measures of self-control. Impulsivity can be thought of as poor response inhibition, i.e., an impulsive individual will act on impulses in an unplanned manner, which may be counter to the way that they had intended (Iribarren, Jiménez-Giménez, García-de Cecilia, & Rubio-Valladolid, 2011). Impulsivity is conceptualised as a

trait and dimension of personality characterised by a predisposition or tendency to act without adequate thought and consideration of future consequences, but can be measured as a state since it is influenced by situational biological and environmental factors (for an overview see Bari & Robbins, 2013). Finally, some studies have measured the personality trait of conscientiousness to assess self-regulatory capacity (e.g., de Bruijn, Brug & Van Lenthe, 2009) given that it may share similar features to self-regulation, such as impulse control and delay of gratification (Bogg & Roberts, 2013; Hofmann, et al., 2008; John & Stivasta, 1999).

As discussed in chapters 2, 3, and 4, a number of researchers have proposed that self-regulatory capacity is important for the enactment of health behaviours (e.g., Hall & Fong, 2007; Hofmann et al., 2009; Strack, & Deutsch, 2004). In relation to eating, there is evidence from individual studies that people who have a better capacity to self-regulate are more likely to eat healthfully than those with poorer ability. For example, Gerrits et al. (2010) found that self-control measured by the Brief Self-Control Scale (Tangney et al., 2004) was positively correlated with self-reported consumption of fruit and vegetables (F&V), and negatively correlated with consumption of fatty foods. In line with this finding, Allen, Vella, and Laborde (2015) reported a significant correlation between self-reported level of conscientiousness and the consumption of F&V. In Study 1, scores on the Brief Self-Control Scale were correlated with the consumption of unhealthy snacks, such that those with higher trait levels of self-control reported that they had eaten fewer unhealthy snacks at follow-up than those with lower levels of trait self-control. Research by Brace and Yeomans (2016) found that participants with better self-regulatory capacity, as measured by behavioural measures of executive functioning, delay of gratification, and impulsivity, ate fewer unhealthy snacks in a laboratory-based taste test.

However, other studies have reported null or contradictory findings. For example, Brummett, Siegler, Day, and Costa (2008) did not find a significant association between self-

reported conscientiousness and diet quality, while de Bruijn, Kremers, de Vries, van Mechelen, and Brug (2007) found that individuals higher in conscientiousness reported drinking *more* sugar sweetened beverages (i.e., less healthy behaviour) than those with lower conscientiousness scores.A non-significant correlation between scores on the Brief Self-Control Scale and eating fewer healthy snacks (e.g., fruit) was found by Adriaanse, Kroese, Gillebaart, and de Ridder (2014). Similarly, in Study 1 trait self-control was not correlated with F&V consumption. Moreover in Study 2 (see Table 4.2), measures of self-control, executive functioning, and delay of gratification were not significantly associated with chocolate consumption in using self-report measures and in a laboratory taste-test.

Given the mixed pattern of results it is, therefore, important to reliably estimate the size and direction of the relationship between self-regulatory capacity and healthful eating and to identify factors that may influence the strength of the relationship. To date, there has not been a systematic and quantitative review that has considered the relationship across all aspects of self-regulatory capacity and healthful eating. Previous reviews have focused on specific measures of self-regulatory capacity; for example, the Stop-Signal Task that assesses only the inhibition dimension of executive functioning (Bartholdy, Dalton, O'Daly, Campbell, & Schmidt, 2016) or the (Brief) Self-Control Scale that measures dispositional self-control (de Ridder et al., 2012). This same issue exists in relation to measures of food consumption. For example, Vainik et al. (2013) sought to review the relationship between the capacity to self-regulate and the outcomes of body mass index (BMI) and eating behaviour, but only included studies that measured the relationship between self-regulatory capacity and laboratory-based measures of food consumption, thereby excluding self-report measures that are widely used in the literature (e.g., the Block food frequency questionnaire, Block et al., 2000). Furthermore, existing reviews have included other related but distinct constructs when assessing self-regulatory capacity or food consumption (e.g., future-oriented temporal

perspective, Sweeny & Culcea, 2017; food selection, Bogg & Roberts, 2004; emotional eating and dieting, de Ridder et al., 2012). A systematic review and meta-analysis is needed to quantify the relationship between self-regulatory capacity and healthful eating, across different aspects of self-regulatory capacity, and to identify factors that influence the strength of this relationship.

5.1.1 What factors influence the relationship between self-regulatory capacity and healthful eating? Three kinds of factors may moderate the relationship between self-regulatory capacity and healthful eating; i) conceptual, ii) methodological, and iii) sample characteristics. Conceptual factors are those that theory suggests will influence the relationship. For example, the aspect of self-regulatory capacity that is measured (i.e., self-control, executive function, delay of gratification, impulsivity, or conscientiousness) may influence the strength of the relationship between self-regulatory capacity and healthful eating since these constructs are theoretically distinct. Another conceptual feature that may influence the relationship between self-regulatory capacity and healthful eating is the healthiness of the food eaten. Based on McEachan et al.'s (2010) classifications, healthy eating can be perceived as an effortful long-term payoff behaviour, while unhealthy eating can be perceived as an easy immediate payoff behaviour. Given the theory that self-regulatory capacity can enable individuals to approach healthy foods and to avoid unhealthy foods (and that these approach and avoidance behaviours are conceptually distinct; Corr, 2013; Hall & Fong, 2007), self-regulatory capacity may show a different relationship to healthy and unhealthy food consumption, however, there is not sufficient evidence to generate hypotheses about the relative strength of the relationships.

A third conceptual moderator is the strength of people's intentions to control their food consumption because eating unhealthy food can only been seen as a failure to self-regulate if the individual has a goal to avoid these foods (Fujita, 2011; Milyavskaya et al.,

2019). Thus, it was predicted that self-regulatory capacity would have a stronger relationship with healthful eating when participants have strong intentions to control their food consumption. A final conceptual moderator is hunger. Dual process theories suggest that visceral states such as hunger can activate fast impulsive/reflexive responses to cues in the environment, before the reflective system has been activated and a rational decision can be made (Evans, 2008; Strack & Deutsch, 2004; Hall & Fong, 2007). This is supported by an experiment showing that compared to those who had eaten just before the experiment, the food choices of participants who were hungry reflected cues in the environment to a larger degree (Cheung, Kroese, Fennis, & de Ridder, 2017). In addition, Nordgren, van der Pligt, and van Harrevel (2008) found that dieters who were hungry placed less important on their weight loss goals and expressed less belief in their ability to stick to a diet. Hunger may, therefore, weaken the relationship between self-regulatory capacity and healthful eating.

The relationship between self-regulatory capacity and healthful eating may also be moderated by methodological factors, such as the way in which the variables are measured and the time between measurements. Evidence suggests that there is low to moderate overlap between self-report and behavioural measures of the same aspect of self-regulatory capacity (Barnhart & Buelow 2017; Nordvall, Jonsson, & Neely, 2017; Toplak et al., 2013). This may be, in part, because self-report, informant-report, and behavioural measures have different task demands, which may introduce measurement bias (Cyders & Coskunpinar, 2011; Friedman & Miyake, 2017). For instance, participants may unintentionally make an error in how they recall their prior behaviour or may wish to present themselves in a socially desirable way on self-report measures (Herbert et al., 1997). There may also be different exposure to food cues and temptations in a laboratory setting compared to daily life, which can influence food consumption (Boswell & Kober, 2016). Common method variance (Podaskoff et al., 2003) may also artificially inflate the correlation between measures of the

same type (e.g., self-reported self-regulatory capacity and self-reported healthful eating) relative to different types of measure (e.g., self-reported self-regulatory capacity and healthful eating during a laboratory taste-test).

The time between measures of self-regulatory capacity and healthful eating may also moderate the relationship between these variables. Cross-sectional designs measure all of the variables at the same time point (e.g., in Study 2), whereas prospective (or longitudinal) studies measure the predictor and outcome at different time points (e.g., in Study 1 the participants answered the Brief Self-Control Scale at time 1 and reported their food consumption 7 days later at time 2). Measuring predictors and behaviour at the same time point may exaggerate the consistency between the responses, particularly for self-report measures, and may overestimate the effects of self-regulatory capacity on intentions compared to prospective designs (Armitage & Conner, 2001; Schacter, 1999). Moreover, it is not possible to infer causation from cross-sectional designs, but directionality can be suggested from prospective studies.

Finally, features of the sample, including their age, gender, and BMI could influence the strength of the relationship between self-regulatory capacity and healthful eating. Evidence suggests that there is a negative relationship between delay discounting and age (Moreira, Barros, Almeida, Pinto, & Barbosa, 2015; Reimers, Maylor, Stewart, & Chater, 2009) and that the separation of facets of executive functioning may change as a function of age (Egbert, Creber, Loren, & Bohnert, 2019; Karr et al., 2018). Age can also influence food consumption as young children have less control over the food that is available to them than teenagers or adults. Furthermore, older adults have a different biophysical and socioeconomic situation to younger adults that can lead to differences in food consumption (Nicklett & Kadell, 2003). Age may, therefore, moderate the relationship between self-regulatory capacity and foods consumed. Second, there is some evidence to suggest that women may be

more susceptible to food cravings than men (e.g., Haynes, Kemps, Moffitt, & Mohr, 2014). As a result, self-regulatory capacity may be required more by females, than by males, to resist food cravings and subsequent consumption of unhealthy foods. Third, evidence suggests that obese individuals show impairment on executive functioning tasks and greater delay discounting than healthy-weight control participants (Fitzpatrick, Gilbert, & Serpell 2013; McClelland et al., 2016; Rotge, Poitou, Fossati, Aron-Wisnewsky, & Oppert, 2017; Smith, Hay, Campbell, & Trollor, 2011; Yang, Sheilds, Guo, & Lui, 2018); therefore, self-regulatory capacity may have a stronger influence on healthful eating for those with a higher BMI.

5.1.2 The present research. Theory suggests that self-regulatory capacity is important for consuming healthy and avoiding unhealthy foods (e.g., Hall & Fong, 2007); however, research testing this proposition has produced mixed findings (e.g., Limbers & Young, 2015). The present review, therefore, sought to systematically review the association between self-regulatory capacity and healthful eating in order to: (i) quantify the strength of the association between self-regulatory capacity and healthful eating using meta-analytic procedures, and (ii) assess the impact of potential moderators on the strength of the relationship between self-regulatory capacity and healthful eating.

5.2 Method

This review followed the PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009).

5.2.1 Selection of studies. Web of Science (Core & Medline), Psych Info, and ProQuest (Dissertations & Theses) were searched for key terms on 16th December 2016 and updated on 28 May 2018. The *search terms* were executive-function* or executive-control or self-regulat* or self-control or impulsiv* or conscientious* or delay* gratification or time-preference AND food-intake or food consumption or eat* or diet* NOT eating disorder* or anorexia or bulimia or binge eating. Additional papers were identified through two routes: (i)

screening the references of articles to be included in the review, and (ii) conducting a forward search in Web of Science for papers citing those included in the review.

Studies had to meet five inclusion criteria. First, the study had to include at least one measure of self-regulatory capacity; defined as the resources and attributes of an individual that enable them to pursue goal directed behaviour and conceptualised as measures of self-control (e.g., the Brief Self-Control Scale, Tangney et al., 2004), executive functioning (e.g., the Behaviour Rating Inventory of Executive Function- Adult; Roth et al., 2005), impulsivity (e.g., the Stop-Signal Task, Logan et al., 1997; UPPS scales of perseverance and premeditation, Whiteside & Lynam, 2001[7]), conscientiousness (e.g., the conscientiousness facet of the 10-item measure of the Big-Five personality dimensions, Gosling et al., 2003), and delay of gratification (e.g., the monetary choice questionnaire, Hardisty & Weber, 2009). The review included measures of self-regulatory capacity in specific, non-eating related, domains such as delay discounting tasks with monetary choices. Scales and tasks that measure self-regulatory capacity in terms of the capability to self-regulate eating behaviour (e.g., delay discounting tasks with food choices or a Stop-Signal Task that uses food images as the stimulus) were deemed likely to have too great of a methodological overlap with the outcome measure of healthful eating (measured by amount of food consumed) and were therefore not included. Measures of self-regulatory processes, for example, goal setting, goal monitoring, and goal operating (e.g., action or coping planning, Schwarzer, 2008) were not included as they reflect performance of behaviours intended to achieve a goal rather than the underlying processes necessary to perform that behaviour (Baird et al., 2017). Furthermore, biometric (e.g., heart rate variability) or neurological (e.g., FMRI) measures were not

[7] The scales of perseverance and premeditation from the UPPS (Whiteside & Lynam, 2001) were included since these have been found to correlate with conscientiousness and impulse regulation, whereas the negative urgency scale and sensation seeking scale were not included as these have been found to be related to the personality dimensions of neuroticism and extra-version (Duckworth & Kern, 2011).

included as, to date, there is insufficient evidence to reliably link specific patterns of activation to self-regulatory capacity (Fiedman & Miyake 2017; Karr et al., 2018).

Second, studies had to include at least one measure of healthful eating as an outcome; for example, the amount of food reported to have been consumed via a food frequency questionnaire or the amount of food consumed during a laboratory taste-test. Measures of food choice and purchasing behaviour were not included since it would not be known if the participant consumed the food that they had chosen/purchased. Third, papers had to report the correlation between self-regulatory capacity and healthful eating (or a statistic that could be converted into effect size *r*, such as an odds ratio). If a study used a manipulation intended to influence self-regulatory capacity or healthy eating, then the study was only included in the review if a correlation or suitable statistic was reported for the relationship between both variables measured before or after the manipulation, or data from a control condition was available. Fourth, papers had to report data for healthy (human) individuals and not a clinical population, including those with an eating disorders or a BMI of ≥ 30 (i.e., obese). Fifth, papers had to be written in English. Where articles reported the variables of interest separately for different subgroups of participants these were treated as separate studies (e.g., Kikuchi and Watanabe (2000), reported data for male and female participants separately).

Figure 5.1 shows the flow of information through the review. Of the 4,408 articles initially identified, 544 duplicates were removed. The title and abstract of the remaining 3,864 articles were screened and 265 were identified as potentially eligible for inclusion. The majority of articles were rejected because they failed to include relevant measures (e.g., the study used a food-specific measure of self-regulatory capacity or measured eating style, such as disinhibited eating, rather than amount of food consumed). The remaining 265 articles were then evaluated in detail. Studies were rejected at this stage if (i) they did not measure self-regulatory capacity and/or the amount of food eaten, (ii) had an inappropriate design

(e.g., self-regulatory capacity was measured prior to a manipulation and food consumption was measured afterwards), (iii) the mean BMI of the sample was ≥ 30, and/or (iv) data was not available to compute the effect size, even after contacting the lead author of the paper.

Next, articles were identified that had been cited by or had cited (and were published before 28th May 2018) each of the 98 papers identified as eligible for inclusion. Of these 9,115 articles, 3,228 were duplicates (i.e., had been identified in the database search or multiple times during the forward/backwards search) and so were removed. Screening (of the title and abstract/full text where appropriate) of the remaining 5,887 articles resulted in an additional 10 articles eligible for inclusion. Two additional articles were identified; one via the author (Study 2 in this thesis) and one via email correspondence with the author of a paper identified as potentially eligible for inclusion (Myrseth & Fishbach, 2009).

Of the 110 articles identified by the database search, citation search, and additional methods, 3 were excluded as outliers at the data analysis stage (Houben & Jansen, 2014; Kuo, Lee, & Chiou, 2016; Tate et al., 2015), meaning that 107 articles reporting 120 studies were included in the review. A list of articles included in the review is provided in Appendix 5A.

5.2.2 Data extraction. Papers were coded to extract information regarding sample size and characteristics (e.g., % female), study design (i.e., cross-sectional or prospective), measure of self-regulatory capacity (i.e., the questionnaire or task used), aspect of self-regulatory capacity (e.g., self-control, impulsivity), measure of foods eaten (e.g., questionnaire, taste-test) and healthiness of foods eaten (as reported by the authors, or following the examples in the coding scheme, i.e., healthy, unhealthy or composite that included both healthy and unhealthy foods, or neutral foods).

The characteristics of the primary papers were coded by the primary researcher and 10% of the studies were coded by a second researcher. There was a high level of agreement (99%) and any disagreements were resolved jointly by discussion. The coding manual is

included in Appendix 5B and the details of the studies included in the meta-analyses are shown in Appendix 5C.

5.2.3 Computing effect sizes. The effect size *r* was computed to represent the strength of the relationship between self-regulatory capacity and healthful eating. An odds ratio (with lower limit and upper limit) or data from independent groups of high and low food consumers (with mean, standard deviation, and sample size per group) was converted into *r* by computer software Comprehensive Meta-Analysis (v.3; Borenstein, Hedges, Higgins, & Rothstein, 2013). Where self-regulatory capacity or healthful eating was measured at multiple time points, data from the longest follow-up point was used. Positive effect sizes indicated that self-regulatory capacity had a positive effect on healthful eating (i.e., eating a greater quantity of healthy foods and/or a smaller quantity of unhealthy foods).

5.2.4 Meta-analytic strategy. The analyses were conducted in Comprehensive Meta-Analysis (v.3; Borenstein et al., 2013). The effect size, 95% confidence intervals and an estimate of heterogeneity were computed for the relationship between all measures of self-regulatory capacity collectively and healthful eating. A random effects model was chosen as it was expected that differences between studies would include random error (Borenstein, Hedges, Higgins, & Rothstein 2010). Following Cohen's (1992) classification, correlations of r = .10, .30, and .50 were taken to represent small, medium, and large effect sizes.

To evaluate the effect of continuous moderators (e.g., average age of the sample, BMI) on the relationship between self-regulatory capacity and healthful eating, a random effects meta-regression model was computed to find the unstandardised correlation coefficient for the proposed moderator, Q statistic, and associated significance. To evaluate the impact of categorical moderators, a random effects model was generated for each level of the moderator and compared using a two-tailed z test. Effect sizes were not computed for subgroups represented by a single study.

5.3. Results

5.3.1 Examination of outliers. Visual inspection of the funnel plot (Figure 5.2) revealed that the effect sizes from three studies were to the right of the expected inverted-V: Houben & Jansen (2014, control condition), Kuo et al. (2016), and Tate et al. (2015). The effect sizes from these studies were more than 3 standard deviations above the sample weighted mean for the whole sample and were therefore removed from subsequent analyses.

5.3.2 The relationship between self-regulatory capacity and healthful eating

There was a small-sized, but statistically significant, positive association between self-regulatory capacity and healthful eating, $r_+ = .08$, $k = 120$, $N = 77{,}705$, 95% CI: .06 - .10, $p <$ .001. Better self-regulatory capacity was related to higher scores on the variable of healthful eating, which was coded such that higher scores indicated that participants in the respective study ate a greater quantity of healthy foods and/or a smaller quantity of unhealthy foods.

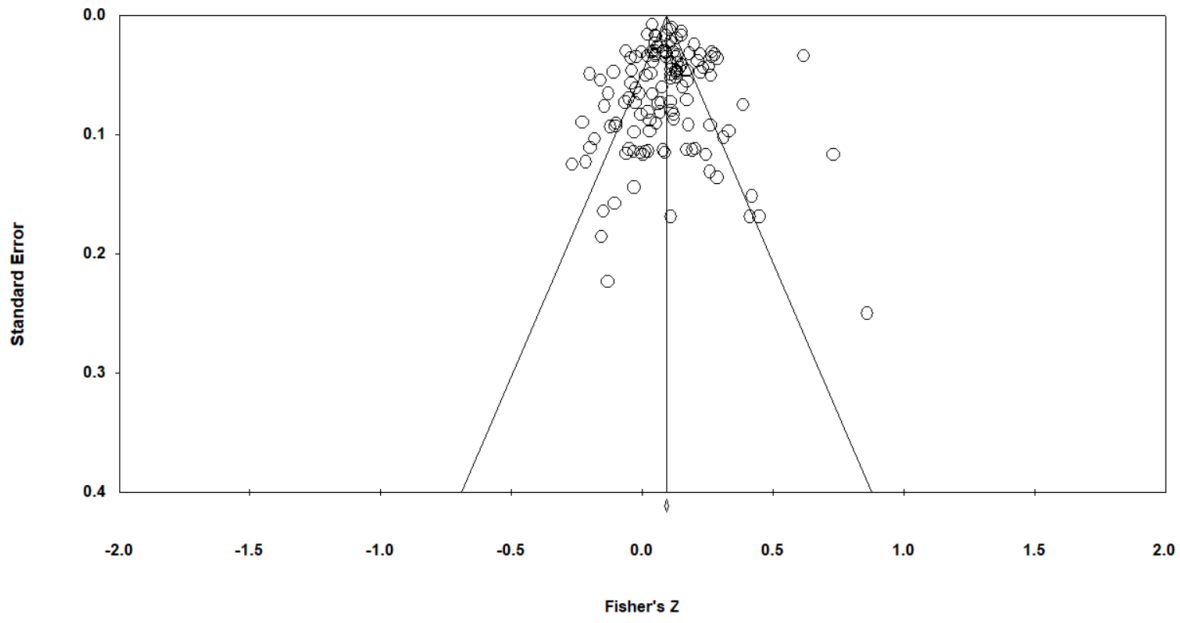

Figure 5.2. Funnel Plot Showing the Effect Sizes from the Primary Studies

5.3.3 Publication bias. Eight unpublished studies were included in the meta-analysis (Adams, 2014; Alexander, 2014; Arad, 2006; Desousky, 2006; Elliot 2013; Ely 2013; Evans, Norman, & Webb, 2018; Myrseth & Fishbach, 2009). Egger's regression (Egger, Davey-Smith, Schneider & Minder, 1997) suggested that the effect sizes were normally distributed around the mean and that there was no bias in the estimate of the relationship between self-regulatory capacity and healthy eating (p = .895). However, comparison of the sample-weighted average correlations between self-regulatory capacity and healthful eating showed that published studies typically reported a small-sized but statistically significant positive association (r_+ = .08, k = 112, N = 76,781, 95% CI: .07 - .10, p <. 001), whereas unpublished studies typically reported a smaller, negative and non-significant relationship (r_+ = .00, k = 8, N = 924, 95% CI: -.07 - .07, p = .983), $Q(1) = 5.52$, p = .019.

5.3.4 Moderators of the relationship between self-regulatory capacity and healthful eating. Cochrane's Q suggested that the effect sizes from the primary studies were heterogeneous and differed more than would be expected by chance, $Q(119) = 606.93$, p <.001. Furthermore, the I^2 statistic suggested that a relatively high proportion of the total variance was attributable to variability between studies rather than sampling error within individual studies, I^2 = 80.39; Higgins, Thompson, Deeks, and Altman (2003) suggest that a value above 75% represents a high level of variance. Factors that may explain variation in effect sizes were therefore explored (see Table 5.1).

Conceptual factors. The aspect of self-regulatory capacity that was assessed in the primary studies significantly moderated the relationship between self-regulatory capacity and healthful eating, $Q(5) = 25.59$, p <.001. Specifically, small or very small-sized, significant, positive correlations were found between measures of self-control (r_+ = .14), impulsivity (r_+ = .13), and conscientiousness (r_+ = .08) and healthful eating (all $p \leq .001$). Measures of delay

Table 5.1. *The Relationship between Self-Regulatory Capacity and Healthful Eating as a Function of the Proposed Categorical Moderators*

	r+	*k*	*N*	95% CI lower	95% CI upper	*Q*
Aspect of self-regulatory capacity						
SC	.14	27	13,119	.10	.17	156.14
Imp	.13	14	5,313	.08	.17	30.91
Cons	.08	30	42,131	.05	.10	81.72
DoG	.06	4	1,107	-.03	.15	8.10
EF	.03	33	10,360	.00	.06	14.58
Between groups Q(5) = 25.59, p < .001						
Healthiness of the food eaten						
Healthy	.08	15	24,517	.03	.12	68.40
Unhealthy	.07	43	14,845	.04	.10	190.03
Composite	.07	22	10,453	.03	.11	78.07
Between groups Q(3) = 1.48, p = .687						
Intention to control food intake						
Yes	.12	8	850	.02	.22	28.11
No	.09	4	380	-.08	.24	3.87
Restrained	.08	3	299	-.09	.24	9.24
Between groups Q(2) = 0.27, p = .876						
Hunger						
High	.06	4	370	-.06	.18	8.92
Low	.05	12	678	-.04	.14	16.70
Average	-.01	8	898	- .09	.06	19.25
Between groups Q(2) = 1.63, p = .654						
Study design						
Cross-sectional	.08	85	56,830	.06	.10	453.91
Prospective	.07	35	20,875	.04	.10	147.40
Between groups Q(1) = 0.19, p = .667						

Type of measure of self-regulatory capacity						
Self-report	.10	80	64,522	.08	.12	387.41
Objective	.02	33	9,145	-.02	.06	106.60
	Between groups Q(2) = 18.83, p < .001					
Type of measure of healthful eating						
Self-report	.09	81	73,101	.07	.11	476.09
Objective	.03	37	3,109	.00	.08	121.75
	Between groups Q(2) = 5.01, p = .082					
Type of measure of healthy eating with objective self-regulatory capacity measures						
Self-report	.02	22	11,539	-.02	.06	51.06
Objective	.01	16	1,260	-.05	.07	54.57
	Between groups Q(2) = 0.68, p = .711					
Type of measure of healthy eating with self-report self-regulatory capacity measures						
Self-report	.10	61	64,833	.08	.12	359.29
Objective	.06	23	2,049	.02	.11	63.15
	Between groups Q(2) = 2.41, p = .300					

of gratification (r_+ = .06, p = .194) and executive functioning (r_+ = .03, p = .074) were not significantly associated with healthful eating.

The healthiness of the food eaten did not significantly moderate the relationship between self-regulatory capacity and healthy eating, $Q(3) = 1.48$, p = .687. Self-regulatory capacity was significantly related to measures of healthy eating (r_+ = .08), unhealthy eating (r_+ = .07), and measures that assessed both healthy and unhealthy food consumption (r_+ = .07), all $p \leq .001$. Greater self-regulatory capacity was associated with greater consumption of healthy foods and lower consumption of unhealthy foods.

The relationship between self-regulatory capacity and healthful eating was not significantly moderated by the strength of participants intentions to control food consumption, $Q(2) = 0.27$, p = .876; that is, the strength of the relationship did not differ between individuals who (i) intended to control their consumption or classified themselves as

on a diet, (ii) individuals who reported they were not controlling their consumption, or (iii) individuals who were restrained eaters. Finally, level of hunger did not moderate the relationship between self-regulatory capacity and healthful eating, $Q(3) = 1.63$, $p = .654$.

Methodological factors. The type of measure of self-regulatory capacity moderated the relationship between self-regulatory capacity and healthful eating, $Q(2) = 18.83$, $p < .001$; self-report measures typically produced a small-sized, but statistically significant, positive association with healthy eating ($r_+ = .10$, $p < .001$), whereas the relationship between objective measures of self-regulatory capacity and healthy eating was smaller and not statistically significant ($r_+ = .02$, $p = .300$). The type of measure of healthy eating did not moderate the relationship between self-regulatory capacity and healthy eating, $Q(2) = 5.01$, $p = .082$; self-regulatory capacity was significantly related to both self-report ($r_+ = .09$) and objective measures of healthy eating ($r_+ = .03$), both $p < .05$.

To test whether common method variance moderated the size of the associations, the relationship between objective/self-report measures of self-regulatory capacity and objective/self-report measures of healthful eating were computed separately. Considering objective measures of self-regulatory capacity, there was no significant difference in the strength of relationships with objective or self-report measures of healthful eating ($Q(2) = 0.68$, p = .711); both correlations were close to zero and non-significant ($r_+ = .01$ and $r_+ = .02$, respectively, both $p > .05$). For self-report measures of self-regulatory capacity, there also was not a significant difference in the strength of relationships with objective ($r_+ = .06$) or self-report ($r_+ = .10$) measures of healthful eating ($Q(2) = 2.41$, $p = .300$), and both correlations were significant, $p \leq .01$.

The relationship between self-regulatory capacity and healthful eating was not significantly moderated by type of study design, $Q(1) = 0.19$, $p = .667$; both cross-sectional

and prospective designs found significant positive relationships between self-regulatory capacity and healthy eating, $p \leq .01$.

Sample characteristics. The average age of the participants was 26.62 (*SD* = 14.37, range 2.46 – 70.22). On average, the percentage of female participants in the primary studies was 67.8% (*SD* = 24.61, range 0 – 100%). Participants in the primary studies had an average BMI of 23.20 (*SD* = 1.71, range 20.38 – 29.22). Meta-regressions indicated that neither age, (β = .00, $Q(1) = 0.08$, $p = .775$), gender (β = .00, $Q(1) = 0.42$, $p = .516$), or BMI ((β = .00, $Q(1) = 0.08$, $p = .812$), moderated the relationship between self-regulatory capacity and healthful eating.

5.4. Discussion

The present review used meta-analysis to investigate the relationship between self-regulatory capacity (i.e., cognitive processes and physiological energy that influence an individual's ability to regulate their behaviour in line with long-term goals and intentions; Hall & Fong, 2007) and healthful eating. The findings of 120 studies with a total sample size of over 77,000 participants indicated that there is a small-sized correlation ($r_+ = .08$) between self-regulatory capacity and healthful eating, such that people with better self-regulatory capacity tend to eat a greater amount of healthy foods and/or a smaller amount of unhealthy foods. This relationship was in the predicted direction; however, it was smaller than might be expected based on theories that highlight the importance of self-regulatory capacity in health behaviour (e.g., Hall & Fong, 2007) and the small-to-medium effect sizes reported in previous reviews of the relationship between single aspects of self-regulatory capacity and food consumption or eating-related behaviours (e.g., de Ridder et al., 2012; Lunn, Nowson, Worsley, & Torres, 2014; Sweeny & Culcea, 2017).

One explanation for the relatively small correlation between self-regulatory capacity and healthful eating found in the present meta-analysis is that although the capacity to self-

regulate is a factor that underlies the regulation and control of behaviour, additional processes are needed for the enactment of health behaviours and monitoring of progress towards the goal (Baird et al., 2017). For example, Control Theory (Carver & Scheier, 1981; 1982; 1990) suggests that after an individual sets a goal, they will need to monitor their progress towards the goal by comparing the actual state of affairs with how they would like them to be, and then take action to reduce any discrepancy. Experimental research demonstrates that self-monitoring and cue-monitoring influence unhealthy snack intake (Maas, Hietbrink, Rinck, & Keijsers, 2013; Verhoeven et al., 2014) and self-regulation across behavioural domains (Harkin et al., 2016). Therefore, self-regulatory capacity may play a small role in the direction of behaviour, compared with other self-regulatory processes.

In addition, self-regulatory capacity can be thought of as the biological limits of an individual's ability to regulate; an individual may not always operate at their upper limit (i.e., their potential capacity is not realised) or state influences may help an individual to exceed their usual ability (Weathers & Siemens, 2018). This may be the case if an individual with high self-regulatory capacity fail to recognise a self-control dilemma. For example, 'breakfast biscuits' marketed as wholegrain, with the inference that this is healthy, can contain as much sugar as a bowl of chocolatey cereal (Action on Sugar, 2016) and an individual may be mistaken about the nutritional content (and healthiness) of such a product if they do not read the nutrition label (Duckworth, Milkman, & Laibson, 2019). An individual with high self-regulatory capacity may consume the breakfast biscuits in the belief that they are healthy; however if the sugar content of their breakfast was analysed by a researcher it may appear as if they were not self-regulating and were eating unhealthily. Moreover, an individual may be mistaken about the positive or negative outcomes of the behaviour (Duckworth et al., 2019).

On the other hand, individuals can use strategies to avoid effortful self-regulation and demonstrate good self-regulatory behaviour even with low trait capacity to self-regulate;

evidence suggests that avoiding triggers and removing temptations can reduce the occurrence of self-regulatory conflicts (Duckworth et al., 2019).

5.4.1 What conceptual factors influence the relationship between self-regulatory capacity and healthful eating? The present meta-analysis found heterogeneity among correlations from the primary studies, which prompted the search for moderators of the relationship between self-regulatory capacity and healthful eating. The aspect (ie., conceptualisation) of self-regulatory capacity significantly moderated the relationship between self-regulatory capacity and eating behaviour. Specifically, measures of self-control, impulsivity, and conscientiousness showed small-sized statistically significant correlations with healthful eating, while measures of delay of gratification and executive function were not significantly correlated. Overall, the finding that aspect of self-regulatory capacity moderated the relationship between self-regulatory capacity and healthful eating is in line with calls for researchers not to use different aspects of self-regulatory capacity interchangeably as if they measure exactly the same construct (Littman & Takás, 2017; Saunders, Milyavskaya, Etz, Randles, & Inzlicht, 2018).

The ability to delay gratification and choose healthy foods (assuming that it has few proximal rewards but long-term positive outcomes) over (tempting but) unhealthy foods is often cited as a stereotypical self-regulation dilemma (Veilleux et al., 2018). The findings from the present meta-analysis, however, showed that delay of gratification was not associated with healthful eating, contrary to expectations. It is worth noting however, that only 4 studies were used in the moderator analysis for delay of gratification and these studies showed a mixed pattern of results. Two studies found correlations in the predicted direction; higher ability to delay gratification (and choose a larger-later reward) was associated with more frequent consumption of breakfast (Daugherty & Brase, 2010), and less frequent consumption of fast food (Garza et al., 2016) in daily life. The remaining two studies found

that higher ability to delay gratification was associated with greater intake of unhealthy snacks in a laboratory-based taste test, i.e., less healthful behaviour (Ely, 2013; Price, Higgs, & Lee, 2016). During the taste test, individuals were only presented with unhealthy snacks; this situation differs from the classical self-regulation dilemma of choosing a healthy over unhealthy behaviour. In the taste tests, the healthier option would have been to limit consumption of the unhealthy snacks, which may generate a different evaluation of the positive and negative outcomes than when choosing between two food items.

The finding that measures of executive function were not correlated with healthful eating was surprising, given that studies have reported that executive function influences healthful eating (for an overview see Dohle et al., 2018; Hall, 2016). Executive functioning is a multi-faceted construct and different dimensions may be differentially related to eating behaviours. For example, inhibition may be required to resist tempting but unhealthy food, while working memory may help an individual to remember their long-term goals and plans to eat healthily or lose weight (Dohle et al., 2018; Hofmann, Schmeichel, & Baddeley, 2012; Miyake et al., 2000). Previous reviews have attempted to code measures according to the dimensions of executive function that they assess; however, there has been inconsistency in the number of dimensions of executive functioning proposed and coding of measures between reviews (e.g., Gray-Burrows et al., 2019; Karr et al., 2018; Yang et al., 2018). Therefore, further research is necessary to develop a scheme for coding measures of executive functions before a more fine-grained analysis of the relationship between this aspect of self-regulatory capacity and healthful eating can be conducted.

The meta-analysis found that the strength of relationship between self-regulatory capacity and healthful eating did not differ significantly depending on whether healthful eating was operationalised as the amount of healthy food consumed, the amount of unhealthy food consumed, or a composite measure of both. Similarly, McDermott, Oliver, Simnadis, et

al. (2015) did not find an association between proposed reflective determinants of behaviour and dietary patterns, which suggests that reflective processes such as self-regulatory capacity are important in the pursuit of healthy behaviour, as well as the avoidance of unhealthy behaviours.

It was further hypothesized that dieting goals would create a self-regulation conflict and strengthen the relationship between self-regulatory capacity and healthful eating. However, no moderation effect was found. This may be explained by findings which show that women who are concerned about their weight did not experience a self-control conflict on a food choice task, and therefore may not recognize the need to use their self-regulatory capacity (van der Laan, de Ridder, Charbonnier, Viergever, & Smeets, 2014). Recent theories of self-regulation highlight the importance of perceiving a desire-goal conflict, as well as adequate self-regulatory capacity, in performing goal-directed behaviour (Kotabe & Hofmann, 2015) and suggest that interventions to improve healthful eating in those who intend to could focus on helping them to recognize situations where self-regulatory capacity is required.

Finally, in terms of conceptual factors, it was predicted that hunger would moderate the relationship between self-regulatory capacity and healthful eating; hunger is a drive that may initiate impulsive or reflexive consumptions responses that occur before effortful self-regulation of behaviour (Hall & Fong, 2007; Loewenstein, 1996). In contrast to predictions, it was found that hunger was not a significant moderator. The interplay between self-regulatory capacity and hunger appears to be more complex than originally conceptualised in Section 5.1.1, and further studies are needed to disentangle the relationship across different situations. For example, hunger can lead to poorer performance on tests of state self-control (e.g., the Stroop task; Gailliot, 2013). However, individuals with a high level of trait self-control experience visceral states such as hunger with less intensity than those with lower self-control

(Baldwin, Finley, Garrison, Crowell, & Schmeichel, 2018) and therefore may be less influenced by hunger. It may be that self-regulatory capacity moderated the relationship between hunger and healthful eating; testing this was outside the theoretical scope of the present meta-analysis, but the relationship between the factors may have influenced the present findings.

5.4.2 What characteristics of the study design influence the relationship between self-regulatory capacity and healthful eating? Self-report measures of self-regulatory capacity showed a significantly larger relationship with healthful eating than objective measures. This is line with expectations and suggests that self-report and behavioural measures capture different information about self-regulatory capacity. Specifically, self-report measures are thought to assess trait-like factors, general tendency, or underlying dimensions of personality, which remain stable across time, while objective measures are thought to give a snap-shot of ability and current state (Cyders & Coskunpinar, 2011; Ellingson, Potenza, & Pearlson, 2018). Furthermore, self-report measures of self-regulatory capacity may allow the respondent to consider self-regulatory processes or strategies that are not captured by a laboratory based task of ability. For example, research from surveys and lab studies suggests that individuals with high self-control may be better at avoiding temptations and thereby self-regulatory failure, than those with low self-control (Ent, Baumeister, & Tice, 2015; Imhoff et al., 2014). It is possible that self-report items such as "I am able to work effectively towards long-term goals" (Brief Self-Control Scale; Tangney et al., 2004) or "makes plans and follows through with them" (Big Five Inventory 44; John & Srivastava, 1990) could index these additional drivers of healthy eating to some extent.

Within the primary studies used in the moderator analysis for 'aspect of self-regulatory capacity', self-control, conscientiousness, and impulsivity were exclusively measured with subjective scales (i.e., self-report or informant report). These aspects were

significantly related to healthful eating. In contrast, only objective measures of delay of gratification, and predominantly objective measures of executive functioning, were used in the studies included in this moderator analysis; these aspects were not found to be significantly related to food consumption. Since type of measure of self-regulatory capacity was found to be a moderator of the relationship between self-regulatory capacity and food consumption, it may have impacted upon the analysis for aspect of self-regulatory capacity. Given the lack of studies assessing self-control, conscientiousness, and impulsivity with objective measures or delay of gratification with self-report measures, it was not possible to further explore this potential confound. Further research with both self-report and objective measures of aspects of self-regulatory capacity is required (Weathers & Siemens, 2018).

There was no difference in the size of the relationship between self-regulatory capacity and healthful eating when food consumption was measured using self-report or objective measures. This finding is in line with a meta-analysis by de Ridder et al. (2012) and, taken together with the lack of evidence that common method variance explains the variability in the relationship between self-regulatory capacity and healthful eating, suggests that both objective and subjective measures could be used to assess the correlates of healthful food consumption patterns in future studies.

5.4.3 What characteristics of the sample influence the relationship between self-regulatory capacity and healthy eating? Age did not influence the strength of the relationship between self-regulatory capacity and healthful eating. This suggests that interventions to strengthen self-regulatory capacity in childhood would have a potential long-term payoff for healthier behaviour across the lifespan. Similarly, gender did not moderate the relationship between self-regulatory capacity and healthy eating. BMI was also found not to moderate the relationship between self-regulatory capacity and healthy eating. Research suggests that there is a significant difference in performance on tests of different aspects of

self-regualtory capacity between participants who are ‘normal’ weight and obese however, some evidence shows this difference is less pronounced between those who are normal weight and overweight (e.g., Lavagino, Arnone, Cao, Soares, & Selvaraj, 2016; Moreira et al., 2015; Rotge, et al., 2017; Wu et al., 2014), which could explain why BMI status did not influence the strength of the relationship between self-regulatory capacity and healthy eating in the present meta-analysis which focused on participants in the normal and overweight range (i.e., BMI < 30).

5.4.4 Implications for interventions. The finding that self-regulatory capacity had only a small relationship to eating behaviour indicates that strengthening self-regulatory capacity within interventions is likely to have only a small impact on food consumption. As such, this may not justify the time and expense of an intervention.

5.4.5 Limitations. The present meta-analysis identified several limitations in the research literature. First, objective measures of general self-control, conscientiousness, and impulsivity are lacking in the literature, as well as self-report measures of delay of gratification. Since type of measure of self-regulatory capacity was a moderator of the relationship between capacity and food consumption, there is an urgent need to use (or develop where necessary) both self-report and objective measures in future studies to further investigate this moderator. Second, relatively few studies (12%) reported participants’ intentions to control the food that they eat. Instead, most studies assumed that healthy eating would pose a self-regulation dilemma to the participants, which may not have been the case and could explain, in part, the relatively small correlation between self-regulatory capacity and healthy eating. Third, more studies focused solely on female participants than on male participants. Gender differences may not be apparent in studies of mixed genders as often the percentage of each gender is not balanced; more research could be conducted to compare across genders. Furthermore, it should be acknowledged that the present meta-analysis

studied the *correlation* between self-regulatory capacity and healthful eating. There is evidence to suggest that the relationship is bidirectional, for example, that eating healthy foods can influence personality traits, cognitive development, and subsequently executive functions such as memory (Allan, McMinn, & Daly, 2016; Allen et al., 2015; Davidson et al., 2019; Hardman, Kennedy, Macpherson, Scholey, & Pipingas 2016). Caution should, therefore, be taken when drawing conclusions about causation from the correlational and prospective studies reported in this meta-analysis.

4.5 Conclusions

The present study used meta-analysis to quantify the relationship between self-regulatory capacity and food consumption and, in line with previous research, found only a small-sized, significant correlation. The aspect of self-regulatory capacity considered significantly moderated the relationship, which strengthens the argument that the various aspects of self-regulatory capacity that have been identified to date (e.g., self-control, ability to delay gratification) are different and should not be used interchangeably (Littman & Takás. 2017; Saunders et al., 2018). The type of measure of self-regulatory capacity also moderated the relationship, with stronger relationships were found between self-report measures and healthy eating; this requires further investigation.

Chapter 6. General Discussion.

The latest figures show that poor diet accounts for 11 million deaths and 255 million disability adjusted life years worldwide, from conditions such as Alzheimer's disease, obesity, cancer, diabetes, and cardiovascular disease (GBD 2017 Diet Collaborators, 2019). The goal of this thesis was to understand the determinants of food consumption and diet quality at an individual level, in part, because these can be used as targets for interventions to increase the consumption of healthy foods (e.g., whole grains or fruit) and decrease the consumption of unhealthy foods (e.g., those high in saturated fat, sugar, and salt). To do this, Temporal Self-regulation Theory (TST; Hall & Fong, 2007) was tested as a descriptive and predictive model of eating behaviour. In Chapter 2, it was suggested that TST would provide a comprehensive model of behaviour since it expands upon social cognitive models, incorporates dual (reflective-impulsive) processes, and acknowledges temporal and environmental influences on behaviour. The theory proposes that beliefs about the connectedness, valence (i.e., positive or negative), and timing (i.e., short- or long-term) of outcomes of behaviour predict intentions to carry out the behaviour (Hall & Fong, 2007). In turn, intentions predict behaviour and the relationship between intention and behaviour may be moderated by behavioural prepotency (i.e., the individuals default response to the environment that may be influenced by biological drives, past behaviour, habits, and cues to action or non-action in the environment) and self-regulatory capacity (i.e., the trait and state ability of an individual to regulate their behaviour in line with long-term goals). Within TST, behavioural prepotency and self-regulatory capacity are also conceptualised as direct predictors of behaviour (Hall & Fong, 2007).

This final chapter will give a summary of the key research findings and discuss implications for interventions and future research directions, with special consideration of how to measure the key constructs of TST and research indicating additional pathways

between constructs that were not explicitly outlined in the original TST model (Hall & Fong, 2007).

6.1 Summary of Key Research Findings

6.1.1 Predictors of intention. Study 1 (Chapter 3) investigated the predictors of healthy and unhealthy eating intentions through a prospective survey. In line with TST (Hall & Fong, 2007) and theories of temporal discounting (e.g., Ainslie, 1975), it was found that the perceived short-term positive and negative outcomes of eating fruit and vegetables (F&V) or unhealthy snacks explained significant amounts of variance in food consumption intentions. A belief elicitation study in the target population of university students (Fishbein & Ajzen, 2010) informed the content of the statements about outcomes of healthy and unhealthy eating. For F&V consumption, the perceived short-term positive outcomes investigated were mental health benefits, feeling healthy, and better quality of life, while the negative outcomes included not feeling full, bad tastes, and high sugar levels. For unhealthy snacking, the perceived short-term positive outcomes investigated were pleasant tastes, positive emotions, and a sugar rush, while the negative outcomes included feeling guilty, ill, or negative emotions (e.g., dissatisfaction). The perceived long-term outcomes (e.g., weight loss for F&V consumption or gain for unhealthy snacking) were not predictive of either eating behaviour.

6.1.2 Predictors of healthy and unhealthy eating behaviour. Study 1 found that the variables specified by TST explained a large amount (64%) of variance in F&V consumption; intention and past behaviour were significant predictors. Moreover, past behaviour moderated the relationship between intentions and behaviour. This finding is in line with theories that healthy behaviour is driven by rational decision making processes (e.g., Ajzen & Madden, 1986), as well as dual-process theories that propose that automatic processes can drive behaviour (e.g., Hofmann et al., 2008 ; Strack & Deutsch, 2004). In the present study, past

behaviour was congruent with intentions and supported the translation of intentions into behaviour, however, the results may have been different if individuals were intending to change their behaviour and act incongruently with how they did in the past (Ouellette & Wood, 1998).

Additionally, Study 1 found that while intention, self-regulatory capacity, past behaviour, and habit strength were correlated with the consumption of unhealthy snacks, the perception of cues in the environment that supported unhealthy snacking was not. This is interesting since cues are hypothesised to be important triggers for unhealthy eating habits and behaviour (e.g., Hall & Fong, 2007; Neal et al., 2011; Wadhera & Capaldi-Phillips, 2014; Wansink, 2004). Furthermore, the results of Study 1 showed that the variables specified by TST predicted less variance in unhealthy snacking beahviour (35%) than in F&V consumption. The non-conscious processes of habit and past behaviour were found to be significant predictors of unhealthy snack consumption; however, these factors did not moderate the relationship between intentions and behaviour. This finding suggests that automatic processes can direct immediate-hedonic behaviours such as consuming unhealthy snacks (McEachan et al., 2010).

Self-regulatory capacity was not found to predict either healthy or unhealthy eating behaviours in a sample of university students in Study 1, and only a small (r_+ = .08) sample-weighted average correlation was found between self-regulatory capacity and healthful eating across all ages in the meta-analysis reported in Chapter 5. The moderator analysis showed that measures of self-control, conscientiousness, and impulsivity were significantly related to food consumption, whereas measures of delay of gratification and executive functioning were not. This is contrary to expectations based on theory and research (e.g., Hall, 2016; Hall & Fong, 2007; Mischel et al., 1989) and confirms that technical terms should not be used interchangeably in the literature (Saunders et al., 2018).

6.2. Implications for Interventions and Future Research

6.2.1 Changing intentions. The findings of Study 1 suggest that interventions to increase the consumption of F&V and decrease the consumption of unhealthy snacks might alter people's perception of, or beliefs about, the proximal outcomes associated with the behaviour by drawing attention to the immediate/short-term, rather than long-term, outcomes of the behaviour. The belief elicitation study (Chapter 3) identified key short-term outcomes of food consumption that could be targeted within interventions for university students, for example, (i) 'myth busting' the perceived negative outcomes of eating F&V, such as not feeling full (e.g., F&V contains fibre that can aid in satiation, or F&V could be a more filling snack if eaten with a source of protein, such as carrots and hummus or apple and peanut butter), (ii) highlighting the positives of F&V consumption, such as 'feeling healthy and nourished', (iii) highlighting immediate negative outcomes of eating unhealthy snacks that an individual may wish to avoid, such as feeling ill or bloated, and (iv) challenging the extent to which positive outcomes of eating unhealthy snacks are experienced (e.g., how filling is a chocolate bar?). The recent 'sugar levy' in the UK draws on the idea of changing the immediate contingencies of unhealthy behaviour by increasing the cost of sugar sweetened beverages; data into the impact on the perceived positive and negative outcomes of purchasing and consuming sugar sweetened beverages, intentions to consume such products, and subsequent behaviour for the UK population as a whole is not yet available (HM Revenue & Customs, 2016).

However, further research into the best methods to change beliefs regarding the valence and timing of outcomes for healthy and unhealthy eating, as well as the impact of changing those beliefs is needed. Research into the framing of health messages has failed to find a consistent and significant impact of valance or temporal framing on eating behaviour, although this research has not adequately investigated the 2x2 dimensionality of

connectedness beliefs (i.e., positive/negative, short-term/long-term) within the same study. For example, Kees (2011) focused solely on the negative (and not positive) short-term and long-term outcomes of fast food consumption and found no main effect of temporal frame on intentions. Furthermore, Kees (2011) tested that the manipulation had influenced beliefs about the timing of outcomes of fast food consumption, but did not test how likely participants thought the outcomes were (i.e., connectedness beliefs). In addition, a study by Brug, Ruiter and van Assema (2003) asked participants to read a booklet with a message about healthy eating (to reduce fat intake or increase F&V intake) and then measured participants intentions to consume the target food; the message was framed as gaining benefits of eating more healthfully, or losing the benefit if behaviour did not change. No difference in intentions was found between those who had read the different frames for either behaviour, but the study failed to assess when in time the outcomes were perceived to occur (Brug et al., 2003). Future research could frame messages about the outcomes of eating behaviour (or use primes, e.g., a picture of someone looking happy or unhappy eating an apple) in a 2x2 factorial design in line with the dimensions of valence and temporality proposed in TST. It would be important to measure changes in connectedness beliefs and temporal valuations, or differences in beliefs between conditions, and the impact on intentions.

The findings of study 1 further suggest that researchers could extent current social cognitive models, which propose a role for an individuals' beliefs in predicting their intentions/goals (e.g., health action process approach, theory of planned behaviour, social cognitive theory) and include an assessment of the temporal dimension of the beliefs.

6.2.2 Increasing healthy eating and decreasing unhealthy eating. Past behaviour predicted F&V consumption, however habits and cues in the environment were not significant in the regression model. As such, interventions could encourage individuals to

focus on the positive outcomes of previous F&V consumption (e.g., feeling healthy, happy, and satisfied) and highlight instance of past behaviour in line with healthy eating goals in order to increase intentions to pursue the behaviour in the future, and future enactment of those intentions (Kassovou et al., 2014; Reynolds et al., 2017; Rothman, 2000). It could be argued that some individuals may have only had instances of past behaviour counter to their intentions so this approach would not work for all individuals. However, research from Bech-Larsen and Kazbare (2014) found that individuals who had tried and failed to change their eating behaviour (either increasing F&V consumption or decreasing unhealthy eating) had higher intentions than individuals who had not tried before; it may be that incongruent past behaviour (e.g., failing to eat an apple as a snack) serves to strengthen motivation to act in line with important goals. Interestingly, most measures of past behaviour only assess if the behaviour has been performed and not instances in which an individual may have intended to act but did not; future research could explore the impact of past enactment of behaviour and missed opportunities to act on intentions and subsequent healthy eating behaviour.

The findings of Study 1 suggest that interventions to reduce the consumption of unhealthy snacks could focus on reducing the strength of habits to consume such items since habit automaticity strength predicted behaviour. Habitual behaviours are those automatically triggered by a cue, and formed through repeated association between the cue and action (Gardner, 2015). Changing strong habits may be difficult, but could be achieved through, i) avoidance or altering of the cues that elicit performance of the undesired behaviour, and ii) by disrupting the usual routine or environment in which the habit occurs (Bamberg, 2006; Lally & Gardner, 2013; Wood & Rünger, 2016). For example, an individual who has a habit of buying a pastry with their morning coffee could disrupt their routine and avoid temptations by choosing to go to a different cafe that does not have pastries available. Supermarkets or

university cafeterias could also disrupt the usual routine of customers by changing the position of unhealthy food items (Bauer & Reisch, 2019).

Furthermore, habits can be beneficial if they are in line with desired behaviour (Carden & Wood, 2018); therefore, interventions could focus on increasing habits to avoid unhealthy foods or replace an unwanted habit with a more desirable one (e.g., swapping a habit of eating chocolate in the afternoon to eating something healthier). Laboratory experiments show that habits for making healthier food choices can be trained using computer tasks (e.g., Lin, Wood, & Monterosso, 2016; Schumacher, Kemps, & Tiggemann, 2016), although the longevity of the intervention effects is often not studied. In research into creating healthy habits in the real world, it has been shown to take an average of 65 days for the new behaviour to become automatic (Lally et al., 2010), which indicates that researchers aiming to manipulate habits should follow participants for at least 9 weeks.

It has also been suggested that habits can be formed for an activity itself, such as eating a piece of fruit, but also for the preparatory actions necessary to enable performance, e.g., buying fruit from the shop (Kaushal, Rhodes, Meldrum, & Spence, 2017). These habits may be further broken down into sub-actions that may cue each-other, such as driving to the shop, walking down the fruit and vegetable aisle, choosing fruit, buying the fruit *et cetera* (Cooper & Shallice, 2000; Vallacher & Wegner, 1987). In addition, habits may play a role in instigating (i.e., starting) performance of a behaviour and executing (i.e., continuing once started) the sequence of actions to perform the behaviour; research indicates that the automaticity of initiating high calorie snacking and eating breakfast explained more variance in behaviour than did the automaticity of executing the behaviour (Gardner, Phillips, & Judah, 2016). As such, Gardner, Rebar and Lally (2019) argue that researchers may need to develop new measures to capture these distinctions in habits, and work towards developing a more comprehensive understanding of habits.

The findings from the present study also indicated that self-regulatory capacity may not be an ideal target for interventions since the relationship between this construct and healthy and unhealthy eating was small; improving self-regulatory capacity may only have a small impact on food consumption, which may not justify the time and expense of an intervention. If an intervention developer did want to target self-regulatory capacity, then self-control, conscientiousness, and impulsivity may be the best aspects to modify, given that they showed the strongest correlation to unhealthy eating. It should be noted that although these constructs are often presented as traits, evidence suggests that they are modifiable (Iribarren et al., 2011; Roberts, Lejuez, Krueger, Richards, & Hill, 2014). Nevertheless, research has also demonstrated an effect of improved executive functioning on healthier eating behaviour, which would not have been hypothesised based on the findings of the meta-analysis. For example, Allom, Mullan, and Hagger (2016) found a small-sized effect of inhibition training on eating behaviour ($d_+ = 0.37$, $k = 14$). Although, this effect was stronger when behaviour was measured immediately after the manipulation, which suggests that it may not be an effective intervention for sustained behaviour change in the real world (Allom, Mullan, & Hagger, 2016).

Finally, given the financial and time constraints on the present research, the studies were correlational; it was not possible to test if changes in the variables specified by TST produced changes in behaviour over time. However, other studies have found support for this idea. For example, Reuter et al. (2010) found that changes in intention predicted changes in F&V consumption 4 weeks later, above the variance accounts for by intentions measured at time 1. Experimental manipulations act as evidence that changes in prepotent responses (i.e., habits), self-regulatory capacity, and the environment can impact on food choice and consumption (e.g., Allom, et al., 2016; Lin et al., 2016; Salmon et al., 2015). Although, it is not always the case that changes in the theoretical determinants of behaviour will translate to

changes in food consumption and this suggests that the conditions under which manipulations or interventions are successful should be researched further.

6.2.3 Measurement of constructs. One of the key contributions of this thesis was to investigate how to measure the constructs specified in TST. Accurate measurement is vital to identify the determinants of healthy and unhealthy eating, and to develop and evaluate behaviour-change interventions (Bartholomew & Mullen, 2011). Study 1 developed and tested a novel measure of the predictors of intention that captures the perceived connectedness, valence, and timing of outcomes. This builds on previous methods that have only tested the likelihood and valence, or the timing of perceived outcomes of behaviour (e.g., outcome expectancies; Schwarzer, 2008). Black, Mullan, and Sharpe (2017) measured connectedness beliefs and temporal valuations for consuming alcohol, however their method was specific to the target behaviour and does not differentiate beliefs about the short- and long-term outcomes as clearly as in the present thesis. The method used in Study 1 is easy to replicate and test TST for other behaviours, such as alcohol consumption, but also smoking and physical activity, which are modifiable risk factors for the development of chronic disease (WHO, 2013). Recent research has tested TST as an explanation of supplement use and a collection of healthy lifestyle behaviours including physical activity, sleep, and breakfast consumption (Allom, Mullan, Clifford, & Rebar, 2018; Booker & Mullan, 2013). However, these studies did not investigate the predictors of intention within the TST model. Since it was found that intention was a significant predictor of supplement use, a better understanding of the predictors of intention could help to increase intentions and subsequently behaviour (Allom et al., 2018).

The present research measured the construct of habits in terms of automaticity, using a validated scale (Gardner, Abraham et al., 2012). This method may capture the extent to which the habit is initiated by automatic processes (Gardner et al., 2016), which is likely to

be suitable for testing the domain of behavioural prepotency within TST. However, this measure may not be a good indicator of how automatically behaviours are executed once they have been initiated (Gardner et al., 2016) and there is currently debate (beyond the scope of this thesis) into how to conceptualise and measure habits for different behaviours with different levels of complexity (for an overview see Mazar & Wood, 2018; Mullan, & Novoradovskaya, 2018; Rebar, Gardner, Rhodes, & Verplanken, 2018). These issues must be taken into consideration by researchers when choosing a measure of habits that is suitable for their research question.

The results from studies 1 and 2 showed that self-report and objective/behavioural measures of general self-control were not reliably correlated with intake of unhealthy snacks and mirrored the conflicting findings in the literature on the relationship between self-regulatory capacity and eating behaviour. A systematic review and meta-analysis was conducted to quantify the relationship between food consumption and self-regulatory capacity across different conceptualisations (i.e., self-control, executive functioning, delay of gratification, impulsivity, and conscientiousness) and measurement methods (i.e., self-report and objective). One hundred and twenty studies that reported the appropriate correlation were included in the analysis and it was found that overall (across the measures) the relationship between the variables was $r = .08$. There was no evidence that common method variance inflated the correlation between measures of the same type (Podsakoff, 2003). An important finding, however, was that within the studies used in the moderator analysis self-control, impulsivity, and conscientiousness were measured with self-report measures, and executive functioning and delay of gratification were measured with objective measures; type of measure may have confounded the analysis of aspect of self-regulation or vice-versa. This finding points to a huge limitation in the evidence base in terms of the diversity of measures for self-regulatory capacity and their use in research. Future studies into self-regulation of

eating behaviour should focus on developing and testing measures to fill the current gaps (de Ridder, Kroese, & Gillebaart, 2018; Weathers & Siemens, 2018). This must be achieved before progress can be made in understanding the relationship of self-regulatory capacity to food consumption and the conditions under which it varies.

In this thesis, self-regulatory capacity, as it relates to TST (Hall & Fong, 2007), was defined as the processes and physiological energy that influence an individual's capacity to self-regulate. This thesis considered self-reported levels and also behavioural outputs of capacity to self-regulate, however, it is also possible to use neurophysiological and neuroimaging measures to assess biologically based self-regulatory capacity and physiological energy; e.g., research suggests that brain regions such as the dorsolateral prefrontal cortex are involved in food related self-regulation (Han, Boachie, Garcia-Garcia, Michaud, & Dagher 2018). In a recent meta-analysis of 7 studies modulating activity in the dorsolateral prefrontal cortext with non-invasive brain stimulation Lowe, Vincent and Hall (2017) failed to find evidence that experimentally induced changes in brain functioning led to changes in food consumption. Moreover, they concluded that the effects were not reliable across studies and research in this area was limited (Lowe et al., 2017). Friedman and Miyake (2017) suggest that research in this area has grown in the last 20 years and has established neural areas that are activated by tests of self-regulatory capacity, however, research has not reliably identified brain regions (e.g., patterns of activation in certain areas or brain structure) that predict individual differences in performance. Further research in this area is needed before physiological measures could be included in a study as the only assessment of self-regulatory capacity.

6.2.4 Additional pathways between TST constructs. Hall and Fong (2007; 2010) propose that TST is more comprehensive than previous social cognitive model of behaviour since it proposes a role for impulsive and reflective processes (i.e., behavioural prepotency

and intention/self-regulatory capacity, respectively). However, dual-process models, such as that by Hofmann et al. (2008) also include consideration of these factors, as well as interaction between the constructs that was not articulated within the original TST model (Hall & Fong, 2007). TST proposes that behavioural prepotency and self-regulatory capacity are independent predictors of behaviour and have the potential to moderate the relationship between intentions and behaviour depending on the environmental context in which the behaviour occurs. Hofmann et al., (2008) suggest that self-regulatory capacity moderates the relationship between impulsive processes and behaviour; individuals act on their impulses when self-regulatory capacity is low (e.g., executive functioning is weak or trait self-control is low), but high self-regulatory capacity may weaken the influence of habits, internal drives or environmental cues on behaviour. Indeed, Hall and Fong (2015) agree that adding a link between self-regulatory capacity and behavioural prepotency would reflect findings that strong executive functioning can 'derail' impulse driven behaviour or habits of inactivity and low prepotency to engage in the behaviour. This link seems inherent in the original conceptualisation of self-regulatory capacity within TST as necessary to suspend prepotent responses, but was not incorporated into the diagram (Hall & Fong, 2007); see Figure 2.1.

An extended model of TST was explicitly tested by Black et al. (2017) in relation to alcohol consumption. The researchers found that inhibitory control (a dimension of executive functioning and self-regulatory capacity) moderated the relationship between behavioural prepotency (as assessed by a composite of past behaviour, habits, and cues that promoted consumption) and heavy episodic drinking; the impact of behavioural prepotency on behaviour was weaker when participants had high inhibitory control (Black et al., 2017). Moreover, the extended model explained greater variance in behaviour than the standard model (Black et al., 2017), which suggests that this extended model could be tested in relation to food consumption.

Hofmann et al., (2009) direcly tested the moderating effect of executive attention and inhibitory control (measured by an Operation Span task and Stop-Signal Task respectively) on the relationship between automatic affective reactions to candy and candy consumption. Automtic affective reactions can be thought of an impulsive process within the domain of behavioural pre-potency in TST, in contrast to reflective and reasoned attitudes, beliefs or intentions (Hofmann et al., 2008). The expected moderation effect was found; the impact of automatic affective reactions on candy consumption during the taste test was significantly weaker for those with higher self-regulatory capacity (Hofmann et al., 2009). Haynes et al. (2015) extended this research my experimentally manipulating automatic attitudes towards energy-dense snack foods. The results showed that participants who repoted low inhibitory self-control (de Ridder, de Boer, Lugtig, Bakker, & van Hooft, 2011) and had been trained to associate unhealthy snacks with negative stimuli ate less of those foods in a subsequent taste test than did those trained to associate unhealthy snacks with positive stimuli (Haynes et al., 2015). In contrast, there was no effect of the training on food consumption for participants with high self-control, which suggested that self-regulatory capacity moderated the effect of impulsive processes on food consumption. These research studies support the proposed moderation effect when self-regulatory capacity is measured via objective and subjective measures. Future research could explore the relationship between other dimensions of self-control and aspects of behavioural pre-potency (e.g., past behaviour, habits or cues) and eating behaviour in the real world.

Nevertheless, evidence indicates that there is an interplay between aspects of behavioural prepotency and self-regulatory capacity; individuals with better self-regulatory capacity are able to avoid visceral states that may undermine self-control or increase the chances of acting on impulses. For example, Baldwin et al. (2018) aggregated data across multiple studies with 5598 participants and found that individuals with high scores on the

Self-Control Scale (Tangney et al., 2004) repoted experiencing less intense visceral (drive) states, such as hunger. The relationship between trait self-control and hunger was mediated by the number of hours since last food consumption, which led the researchers to suggest that those with higher self-control are better able to avoid intense visceral states by managing their behaviour (Baldwin et al., 2018).

Research also shows that children (8 to 13 years old) with low self-control rate unhealthy foods as tastier than healthy foods and prefer the taste of unhealthy foods (Ha, Lim, Bruce, & Bruce, 2019). On the other hand, despite a biological disposition towards salty and sweet foods (Birch, 1999), children with high self-control indicted that they thought healthy and unhealthy foods were equally tasty and showed no preference for either (Ha et al., 2019). In line with these results, Haynes et al., (2016) found that higher self-control was related to lower desire strength for unhealthy snacks and lower consumption in a sample of adult women with a healthy eating goal. Gillebaart and de Ridder (2015) explain that those with high self-control are better able to downregulate goal-incougurent impulse and thus response conflict, which means that less self-control needs to be exterted in the moment and goal-congurent behaviour is more likely. Additional research shows that those with high self-control are faster at identifying and resolving conflicting goals and desires that do arise (Gillebaart, Schneider, & de Ridder 2016; Stillman, Medvedev, & Ferguson, 2017).

High trait self-regulatory capacity may also enable individuals to employ strategies to avoid temptations and triggers to unwanted behaviours (Duckworth et al., 2016; Ent et al., 2015; Hofmann, Baumeister, et al., 2012). Self-control may also enable individuals to arrange environmental cues in such a way as to promote the formation of beneficial habits which may allow them to engage in less effortful inhibition of undesired responses (Duckworth et al., 2016). Adriaanse et al. (2014) found that better trait self-control was related to weaker habits of eating unhealthy snacks, however there was no relationship to

F&V consumption habits. The role of self-regulatory capacity in developing and strengthening healthful eating habits requires further research. It has been suggested that the formation of habits may require attention to cues and inhibitory control to override other desires; processes that fall under the construct of self-regulatory capacity (Anderson, 2016; Carden & Wood, 2018; Luque et al., 2017). However, once formed, a habit can enable individuals to enagage in less effortful inhibition of behaviour (Adriaanse et al., 2014).

The interplay between behavioural prepotency, self-regulatory capacity, and behaviour appears to be more complex than initially outlined in TST and future research should take this into consideration.

6.3 Overall Conclusions

This thesis tested TST as an explanation for healthy and unhealthy eating intentions and behaviour, and thus makes an important contribution to the research literature on theories of health behaviour. Overall, the findings indicate that behavioural prepotency (which includes drives, past behaviour, and habits, and operates outside of conscious awareness) and reflective processes (i.e., intentions and the capacity to self-regulate) impact eating behaviour; this suggests that both aspects should be considered by theories of health behaviour and the developers of interventions to change food consumption patterns. However, the effect of intention, behavioural prepotency, and self-regulatory capacity was not consistent across behaviours or studies in this thesis. As suggested by Hall and Fong (2007), the context in which the behaviour takes place may influence levels of intention, behavioural prepotency, and self-regulatory capacity, and their impact on behaviour. In addition, the meta-analysis reported in Chapter 5 indicates that conceptual and methodological factors in study design can influence the statistical relationship between self-regulatory capacity and behaviour. Furthermore, the interplay between aspects of behavioural prepotency (e.g., salient cues in the environment that trigger behaviour or automatic affective

reactions) and self-regulatory capacity was not depicted within the original articulation of TST, but may influence which factors predict behaviour at a given moment. In light of these findings, future directions for research into understanding the determinants of eating behaviour and changing behaviour patterns were outlined in Chapter 6.

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