Understanding people's response to affective text messages and personalisation

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Presentations

MEIBioeng15 Conference (September 2015) – University of Leeds, Leeds, UK. 2nd place for best poster presentation.

Poster: A study of psychophysiological measures comparing people's reactions to tailored affective and cognitive text messages to increase physical activity

1st Behaviour Change Conference: Harnessing Digital Technology for Health Behaviour Change (February 2015) – UCL, London, UK.

Poster: Using psychophysiology to assess the arousal and valence associated with affective and cognitive behaviour change text messages.

International Digital Health and Care Congress (September 2014) – The Kings Fund, London, UK.

Presentation: Using psychophysiology to study the emotional impact of words used in behaviour change text messages.

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Presentation: Psychophysiological measures to explore affect in text messages for behaviour change.

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Presentation: Psychophysiological methods to study the emotional impact of words used in physical activity text messages.

XI Symposium for Mexican Students and Studies (July 2013) – University of Sheffield, Sheffield, UK.

Poster: Can emotions inform the design of SMS text messages for health behaviour change?

Abstract

The obesity and overweight growing rates are a major global concern for both developed and developing countries. Digital technologies can potentially deliver effective interventions to tackle this crisis, with mobile phones uniquely positioned to deliver scalable, real-time, inexpensive, and interactive support for all at risk.

A meta-analysis showed that SMS interventions are effective for promoting weight loss and physical activity. The content of SMS messages of digital behaviour change interventions is usually seen as the main driver of effectiveness. It has been suggested that personalised communication, reaching people on emotional as well as rational levels, is more effective.

However, there is no previous study exploring people's affective responses to message wordings and personalisation, which could lead to more effective tools for promoting healthier behaviours, like physical activity. Affect is a term used to define the experience of a feeling or an emotion. Psychophysiological and self-reported measures of arousal and valence, the two main dimensions of emotions, were used to measure message impact on different levels of consciousness; and as methods to better understand people's response to affective messages and personalisation.

The first study in this thesis examined electrodermal activity and facial electromyography as objective measures of arousal and valence, respectively, and found strong associations between these measures. Study 2 compared psychophysiological and self-reported responses to previously evaluated affective and cognitive messages but found no significant difference between them. Study 3 used the same methods to test the effect of personalisation of affective and cognitive messages using identification (participant's name) and contextualisation (participant's preferred physical activity). Personalisation of messages using contextualisation and identification were found to be effective strategies for eliciting emotional responses and persuasiveness.

This thesis contributes to our knowledge about using psychophysiology and self-report as methods to measure people's response to affective and personalised messages, and the value of measuring the emotional impact of text messages on the recipient before using these in randomised controlled trials. The developers of SMS interventions and other digital techniques could benefit from using these methods. Future work needs to investigate the impact of messages designed using these methods on actual behaviour.

Abbreviations

ANEW	Affective norms for English words
BMI	Body Mass Index
CS	Corrugator supercilii
EDA	Electrodermal activity
fEMG	Facial electromyography
ICT	Information and communications technology
MET	Metabolic equivalent of task
mHealth	Mobile health
OECD	Organisation for Economic Co-operation and Development
PA	Physical activity
PPA	Preferred physical activity
SMS	Short message service
UK	United Kingdom
WHO	World Health Organization
ZM	Zygomaticus major

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Introduction

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1.1 Obesity and physical activity

1.1.1 Obesity

The World Health Organisation (WHO) defines obesity and overweight as the abnormal or excessive accumulation of fat that may impair health. More than 1.9 billion adults worldwide were overweight in 2014; 600 million of these were obese, representing about 13% of the world's adult population. In 2013, the number of overweight and obese children under five years of age was estimated to be over 42 million, of which 31 million lived in developing countries (WHO, 2015a). More than half of the adult population in the Organisation for Economic Co-operation and Development (OECD) were reported to be overweight or obese (OECD, 2014a). Data from ten OECD countries confirm that the obesity crisis has not stopped spreading; however, rates have been increasing at a slower pace in the past five years than previously seen (OECD, 2014b).

This dramatic increase in adult overweight and obesity rates over the past 20 years has made organisations, governments, media, researchers and the general population pay special attention to this global health problem. A body mass index (BMI) of over 25 kg/m^2 leads to a higher risk for non-communicable diseases such as cardiovascular diseases (mostly heart disease and stroke), diabetes, musculoskeletal disorders, and endometrial, breast and colon cancers. As a result of this, the WHO estimates that at least 2.8 million adults die every year as a result of being either overweight or obese.

Governments around the world have introduced policies on food labelling, taxation of foods with high caloric content and sugar-sweetened beverages, and television and radio advertisement regulations to protect children, in an effort to address obesity (Dávila-Torres, González-Izquierdo, & Barrera-Cruz, 2015; Fao, 2013; OECD, 2014b). These policies differ between countries and are neither long-lasting nor stringently applied. More common are media campaigns designed to promote physical activity and healthy eating, social programmes delivering healthy food to people in rural areas, internet campaigns and other strategies to change people's behaviour.

1.1.2 Physical activity

Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen, Powell, & Christenson, 1985). It includes walking, dancing, hiking, swimming, games, carrying out household chores, gardening, and walking or cycling as a way of transportation. Exercise, on the other hand, is a subcategory of physical activity and should not be confused with physical activity. It is defined as physical activity that is planned, structured, repetitive, and aimed at improving or maintaining one or more components of physical fitness (Caspersen et al., 1985).

The recommended levels of weekly physical activity for adults between 18 – 64 years of age are for at least 150 minutes of moderate-intensity aerobic physical activity, or a minimum of 75 minutes of vigorous intensity aerobic physical activity, or an equivalent combination of the both; strength exercises should also be done on two or more days a week (NHS, 2015).

According to the WHO (2015b), 1 in 4 adults in the world are not active enough, more than 80% of the world's adolescent population is insufficiently active and approximately 3.2 million deaths worldwide are attributable each year to insufficient physical activity. Insufficient physical activity contributes to obesity and some of its consequences include increasing the risk of a range of non-communicable diseases like coronary heart disease, type 2 diabetes, and breast and colon cancer (Lee et al., 2012; Wijsman et al., 2013).

The WHO (2015b) reports that engaging at an adequate level of physical activity:

- improves muscular and cardiorespiratory fitness;
- improves bone and functional health;
- reduces the risk of hypertension, coronary heart disease, stroke, diabetes, breast and colon cancer, and depression;
- reduces the risk of falls as well as hip or vertebral fractures; and
- regulates energy balance and weight control.

In 2011, it was estimated that the direct cost of physical inactivity to the NHS across the UK was of £1.06 billion (Department of Health, 2011). King et al. (2000) reported that environmental factors like fear of violence and crime outdoors, low air quality and pollution, and lack of parks, sidewalks and sports/recreational facilities have discouraged people from becoming more active; other perceived barriers identified were lack of time, caregiving duties, tiredness, self-consciousness about physical appearance and bad weather.

There have been worldwide efforts to encourage people to be more active. Boccia & Zimmern (2015) provide some examples of multidisciplinary actions to increase levels of physical activity that appear to be cost-effective:

- social support - offered in different settings such as schools, worksites and communities;
- transport policies - such as creating cycling lanes and easy access to community leisure centres;
- primary care support; and
- community-wide campaigns through mass media and social network.

Physical activity programmes delivered by governments around the world, such as: *Let's Move!* in the United States of America, *Let's Make Scotland More Active* in Scotland or Mexico's *Programa Nacional de Cultura Física* (National Programme for Physical Culture), all report positive results.

The use of internet technology by the public, health workers and others to access health and lifestyle information, services and support is known as eHealth (Wyatt & Liu, 2002). Research exploring eHealth to assess and intervene on physical activity using different delivery methods has been undertaken for at least the past 15 years. Some of its advantages for health promotion are: reduced personnel demand, interactivity and flexibility, automated data collection and the potential for more honest self-report by participants (Evers, 2006). Some of the methods used to deliver physical activity interventions include internet websites (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012; Duncan et al., 2014), email

(Plotnikoff, McCargar, Wilson, & Loucaides, 2005) and personal digital assistants (King et al., 2008).

The practice of medicine, nursing and public health supported by mobile devices is known as mHealth (Shaw & Bosworth, 2012), a relatively new field which is considered to be a sub-category of eHealth. Mainly there are two methods that have been used to deliver physical activity interventions: text messaging (Prestwich, Perugini, & Hurling, 2010; Sirriyeh, Lawton, & Ward, 2010) and mobile phone application software (apps) (Middelweerd et al., 2015; Rabbi, Pfammatter, Zhang, Spring, & Choudhury, 2015).

1.2 Tackling obesity and physical activity

1.2.1 mHealth

New technologies and wearable devices have a direct impact on how we live, how we do things, and how we communicate, moving from just being a technological object to a key social object. (Srivastava, 2005; Thulin & Vilhelmson, 2007). Data from the International Data Corporation (2015), showed that vendors shipped a total of 334.4 million smartphones worldwide in the first quarter of 2015, with Samsung retaining its leadership in the smartphone market, and Android-based systems dominating the market with 78% of the share.

The information and communications technology (ICT) data and statistics division of the International Telecommunications Union (2015) forecasts that by the end of 2015 there will be more than 7 billion mobile phone subscriptions. This corresponds to a 97% penetration of the world's population. Ofcom, the independent regulator and competition authority for the UK communications industries, reported 88.4 million mobile phone subscriptions for the last quarter of 2013.

The WHO has been a great supporter of mHealth, especially in developing countries, seeing it as a transformational technology. One of the advantages of mobile phones is that they are uniquely positioned to bridge the gaps in health disparities and reach across demographics (Militello, Kelly, & Melnyk, 2012).

There has been a recent interest in mobile phone apps, but the short message service (SMS), a mobile phone component, has been studied for health applications since 2002 (Neville, Greene, McLeod, Tracey, & Surie, 2002). SMS gained quick popularity when it was made available in 2000, mainly because of its relatively low cost (Taylor & Vincent, 2005). An average of 138 SMS and multimedia messaging service (MMS) messages were sent per person per month in 2013, as reported by (Ofcom, n.d.).

Although still popular, there has been a slight decline in SMS usage. Ofcom also reported that for 2014, the average monthly number of SMS and MMS dropped by 18%, to 117 messages. There has been a shift from using SMS to other messaging applications and social media services, such as Twitter, WhatsApp and Instagram, especially among young people. This is also being seen in adults who have an online presence (Ofcom, 2015b).

Among the emerging health care delivery technologies, mobile phones currently provide the greatest opportunity for personalised, private and easy access to information through the use of SMS (Preston, Walhart, & O'Sullivan, 2011). SMS-delivered interventions have been found to have positive short-term behavioural outcomes (Fjeldsoe, Marshall, & Miller, 2009; Johnston, Hoffman, & Thornton, 2014). Bouhaidar et al. (2013) and Shaw et al. (2013) found SMS as an effective way to deliver weight loss interventions in a 12-week evaluation period. The same has been demonstrated for smoking cessation interventions (Spohr et al., 2015) and binge drinking (Suffoletto et al., 2014).

1.2.2 Behaviour change mHealth interventions

A behaviour change intervention is '*an activity or coordinated set of activities that aims to get an individual or a group of people to behave differently from how they would have acted without such an action'* (Michie, Atkins, & West, 2014). Different theories have been developed to help modify people's behaviour towards a more active lifestyle. The meta-analysis of Williams & French (2011) found that social cognitive theory, the transtheoretical model and the theory of planned behaviour were reported to be most commonly used for physical activity interventions.

The introduction of digital technologies provided an opportunity to deliver behaviour change interventions using the internet, computers and mobile devices to reach wider groups of people. Technology-based interventions promoting physical activity have been found to be effective (Connelly, Kirk, Masthoff, & Macrury, 2013).

Mobile phones are carried by people wherever they go and provide a channel to deliver interventions at an individual level (Free et al., 2013). Evidence supports the use of mobile technologies to reach people, promote healthier behaviours and support behaviour change. Behaviours such as smoking cessation have been successfully tackled using SMS text messages (Spohr et al., 2015). A growing number of studies have explored text messages as a tool to design and deliver behaviour change interventions for physical activity with mostly favourable results (Kim & Glanz, 2013; Prestwich et al., 2010; Schwerdtfeger, Schmitz, & Warken, 2012; Sirriyeh et al., 2010).

However, little is known to date about what makes an intervention effective, and there is still a great deal that is unknown about how mHealth interventions work. Little is known about whether the mainly short-term effects of these interventions can be translated into long-term effects as there is a lack of long-term results (Hall, Cole-Lewis, & Bernhardt, 2015; Siopis, Chey, & Allman-Farinelli, 2014). Intervention engagement still needs to be further explored in addition to which interventions characteristics are likely to lead to intervention effectiveness. To answer these and other questions more rigorous trials are required (Stephens & Allen, 2013).

1.3 Health communication

Health communication includes the examination of communication in the delivery of care, health promotion, development and use of eHealth, dissemination of health risk information and the operation of health care systems (Kreps, 2012). Studies that have explored the effects of health campaigns have found small measurable short-term effects, but addictive behaviours have been shown to be particularly difficult to change (Snyder et al., 2004).

A meta-analysis by Keller & Lehmann (2008) on designing effective health communication found that focusing on social or physical consequences, emotional messages, and discouraging unhealthy behaviours are message tactics that enhance health intentions. According to Neuhauser & Kreps (2003), health communication for improving behaviour change is more effective when it:

- reaches people at an emotional and rational level;
- relates to people's social or life contexts;
- combines interpersonal and mass media reach;
- is interactive; and
- is tailored.

1.3.1 Intervention tailoring and message personalisation

The content of SMS messages used by mHealth SMS-based interventions is generally seen as the central driver of behaviour change interventions (Militello et al., 2012). Message tailoring and personalisation had been associated with greater intervention efficacy (Head, Noar, Iannarino, & Grant Harrington, 2013) for health promotion interventions, showing statistically significant effects ($d = 0.442$) on health behaviour. Furthermore, the way messages are framed can affect whether a person is receptive to making a behaviour change (Rothman, Salovey, Antone, Keough, & Martin, 1993). For example, Fjeldsoe et al. (2010) targeted post-partum women to increase their frequency of engaging in moderate to vigorous physical activity using tailored SMS. These messages included participant's name, social support person's name, the physical activity goal, nominated physical activity rewards, and preferred physical activity options. This intervention successfully increased physical activity frequency for participants in the intervention arm.

Tailoring is a process for creating individualised communications (Rimer & Kreuter, 2006). The tailoring strategies proposed by Hawkins et al. (2008) include personalisation, feedback and content matching. Personalisation strategies have been commonly used to enhance message processing and, in some cases, they may affect behaviour (Dijkstra, 2005). The types of personalisation proposed by Hawkins et al. (2008) include:

- Identification: using the recipient’s name or birthday;
- Raising expectation of customisation: uses statements such as: ‘The following health information has been created especially for you’; and
- Contextualisation: using a person’s subjective reality to make messages more familiar, personally relevant and credible.

1.4 Affect and measuring affect

Emotions have been integrated into the study of health behaviours for more than 60 years (Nabi, 2002). Affect is a term used to define the experience of a feeling or an emotion. Researchers have recognised arousal and valence as two important components of affect in this context (Kensinger & Corkin, 2003; Russell, Weiss, & Mendelsohn, 1989; David Watson & Tellegen, 1985). Mehrabian & Russell (1974) defined arousal as a ‘*unitary emotional response dimension ranging from sleep to frantic excitement’*. Mehrabian and Russell (1974) defined valence (pleasure) as ‘*a feeling state that can be assessed readily with semantic differential measures or with behavioural indicators such as smiles, laughter, and in general, positive versus negative facial expressions*’.

Emotional responses elicited by mass media has been found to be an effective way of changing public health attitudes, intentions and behaviours (Dunlop, Wakefield, & Kashima, 2008). Furthermore, studies have found that the emotional response to messages plays an important role in people’s judgement of perceived message effectiveness, which then shapes people’s attitude (J. P. Dillard & Peck, 2000).

The use of negative emotions has been studied in advertisements for smoking, alcohol, drugs and AIDS prevention (Becheur & Valette-Florence, 2014; Becheur et al., 2008; Biener, McCallum-Keeler, & Nyman, 2000). For example, Becheur et al. (2008) found that fear, guilt and shame, especially, were effective at persuading young people against alcohol abuse. Biener et al. (2000) found that anti-tobacco television advertisements that elicited strong negative emotions of sadness and fear were rated as the most effective by quitters, non-smokers and smokers planning to quit.

Conversely, Previte et al. (2015) found that positively framed advertising concepts (adcepts) evoking happiness and love were reported by alcohol consumers to be more influential for moderate alcohol consumption than negative adcepts. One of the adcepts used in this study showed a couple holding hands enjoying a walk in the countryside; the text referred to weekends, drinking and hangovers. The main message was that it was fine to drink in moderation. For the case of physical activity, positive affective messages have been found to be an effective means to get people to engage in physical activity (Morris, Lawton, McEachan, Hurling, & Conner, 2015; Sirriyeh et al., 2010).

1.4.1 Psychophysiology methods

Psychophysiology studies the relationship between psychological manipulations and physiological responses to understand the relation between mental and bodily processes (Andreassi, 2007). A number of methods and measures are used in psychophysiology. These include electroencephalography (EEG), fMRI (functional magnetic resonance), measures of electrodermal activity (EDA), heart rate variability (HRV), facial electromyography (fEMG) and electrooculography (EOG).

Psychophysiological findings can corroborate or contradict findings from more traditional psychological measures, such as self-report scales and behavioural performance (Edgar, Keller, Heller, & Miller, 2007). Tomarken (1995), in his psychometric perspective on psychophysiological measures, gives two main reasons on why psychophysiological measures can complement other types of assessment. These reasons are:

1. they assess unique processes not tapped by other types of measures, and
2. psychophysiological measures capture more sensitive data.

Tomarken (1995) also favours psychophysiological measures as they can potentially index important processes that underline affective responsivity and are not accessible to consciousness. A study on fear by Ordoñana et al. (2009) found differences between self-report and psychophysiological responses related to subjective perceptions, intentions and reported behaviour.

Two of the least invasive and most common psychophysiological measures are the electrodermal response and facial electromyography.

Electrodermal response

The term electrodermal activity was first introduced by Johnson & Lubin (1966) to refer to all the electrical phenomena in the skin. It means to measure the changes in the skin's ability to conduct electricity as a response of the sympathetic nervous system (through the sweat glands in the skin) to an external stimulus. Electrodermal activity is a reliable and well-established measurement technique for emotional stimuli with its origin going back to 1849 in Germany, where Emil du Bois-Reymond conducted several experiments. These experiments involved human participants placing their hands or feet in a zinc sulphate solution, and an electrical current was observed to go from one limb to the other.

Electrodermal activity is one of the most widely used response systems in psychophysiology history. The use of electrodermal activity measures is mostly due to the relative ease in obtaining a very distinct electrodermal response (EDR), which seems to be related to the stimuli intensity and/or individuals' psychological states and processes (Dawson, Schell, & Filion, 2007). Electrodermal recordings can be endosomatic – recordings do not use an external current – or exosomatic – recordings apply either direct or alternating current.

Electrodermal activity was previously referred to as galvanic skin response (GSR). However, that term is no longer recommended to be used because the skin is not a galvanic element; it suggests that electrodermal responses are elicited as a reflex, which would neither include spontaneous electrodermal responses nor psychologically elicited electrodermal damages. The term galvanic skin response has been used to cover not only phasic electrodermal responses but also electrodermal phenomena in general, including tonic electrodermal activity (Boucsein 2012).

Some advantages of electrodermal activity include:

- it provides a nearly direct and undiluted representation of sympathetic activity;
- its occurrence is generally easy to interpret;
- compared to other psychophysiological measures, it is relatively inexpensive to record, completely harmless and risk-free; and

- it can be used to reference a number of processes such as activation, attention and the significance or affective intensity of a stimulus.

Some of its disadvantages are:

- it is a slow response system (1-3 seconds following stimulus onset);
- multiple causes can activate this system (e.g. coughing);
- internal and external factors (e.g. temperature) are sources of variance; and
- prescribed and over-the-counter medications can have significant effects on skin conductance levels.

In this era of cheap reliable electronics, A/D conversion and data logging technology, it is possible to perform electrodermal recordings with rather inexpensive equipment, thus its popularity. Some of the research areas in which electrodermal activity is used today include emotional states (Lanatà, Valenza, & Scilingo, 2012), lie detection (Kozel et al., 2009), schizophrenia research (Bob, Susta, Chladek, Glaslova, & Fedor-Freybergh, 2007; Nilsson, Holm, Hultman, & Ekselius, 2014), human-computer interaction (Kuriakose, Sarkar, & Lahiri, 2012), marketing and product evaluation (Lajante, Droulers, Dondaine, & Amarantini, 2012), and overcoming social response bias (the tendency of research participants to say what they think the researcher wishes to hear).

There has been scientific debate for a very long time around emotions and what an emotion is. Arousal, the first of the two main components of affect, which ranges from calm to excited, can be measured using the electrodermal phenomena. However, it cannot measure valence, which ranges from positive to negative, and this is electrodermal activity’s main limitation. Focusing only on the arousal dimension using electrodermal activity alone leads to missing important information regarding valence.

To overcome this limitation and to better understand the meaning of a specific electrodermal response to a stimulus, it is required to cross-reference it using another physiological measure, facial electromyography.

Facial electromyography

The human face is regarded as the richest source of information about a person’s affective state (van Boxtel, 2010). Facial electromyography can help quantify valence objectively. This method is widely used in psychology for a variety of purposes. Recordings of facial electromyography in humans were first reported by Edmund Jacobson in 1925. Facial electromyography records the tiny electrical signals involved in facial muscle activity, and due to its quantitative nature, the facial expressions can be analysed by automated systems or algorithms to determine a person’s affective state.

Facial electromyography has been used in research on emotional expressions and masticatory function evaluation, among others. It is also used for emotional stimuli valence diagnosis (Hazlett & Hazlett, 1999; Larsen, Norris, & Cacioppo, 2003; Lindsey, Rohan, Roecklein, & Mahon, 2011), typically evaluating the activations of two facial muscles: corrugator supercilii - which draws the eyebrow down together into a frown - and zygomaticus major - which pulls the corners of the mouth back and up into a smile.

Tassinary et al. (2007) recognised the following advantages of facial electromyography:

- it can be collected continuously without the person’s attention or labour;
- detection and quantification of the signal can be done using computers, which are more sensitive, reliable and faster than fine-grain analyses of apparent behaviour; and
- many subtle psychological processes or events are not accompanied by visually perceptible actions or significant visceral changes, but can be detected by facial electromyography.

Disadvantages of this technique, as presented by Tassinary et al. (2007), include:

- monitoring activity over a single site may only provide ambiguous or global information about the associated psychological or behavioural process;
- imperfect selection of surface electrodes and the close proximity of the various striated muscles make it difficult to pinpoint exactly which muscles are contracting.

Other disadvantages include: the number of muscles that can be measured is limited to the number of electrodes that can be attached to the face, people's awareness of the electrodes may alter natural expression, and certain medications, like muscle relaxants and anticholinergics, can modify the results.

Facial electromyography has been used for marketing research (Benedek & Hazlett, 2005), communication research (Bolls, Lang, & Potter, 2001), autism (Rozga, King, Vuduc, & Robins, 2013), and psychology (J. T. Cacioppo, Bush, & Tassinary, 1992; Larsen et al., 2003).

1.4.2 Neuromarketing

Market research began to make use of psychophysiological measures for marketing purposes and to understand consumer preferences some time ago. This new branch of market research is often referred to as neuromarketing, a concept developed by psychologists from Harvard University in 1990 and later coined by Smidts in 2002 (Ait Hammou, Galib, & Melloul, 2013). Smidts (2002) defined neuromarketing as a '*set of methods used to have a better understanding of the customer and his reaction to marketing stimuli by measuring the processes in the brain (neuroimaging and biometrics) and including them in the development of both theory and stimuli*'.

Neuromarketing is usually related to electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), which are relatively intrusive methods and can be unpleasant for research participants. Other less intrusive methods also used by neuromarketing include behavioural experiments and physiological measures. Some of these measures include eye tracking, facial electromyography, heart rate variability, respiratory rate and skin conductance. The main goal of these methods is to obtain objective information about the workings of the limbic system[1] of the brain of consumers to complement/support the subjective reports that have been the pillar of marketing studies (Murphy, Illes, & Reiner, 2008).

[1] The limbic system is known for supporting emotion, behaviour and motivation. It includes the hippocampus, amygdala, anterior thalamic nuclei, septum, habenula, limbic cortex, and fornix.

There is a vast amount of neuromarketing methods and research in the grey literature. Some marketing research companies that use neuromarketing methods are Milward Brown, Sands Research and Neurosense. In 2012, Milward Brown announced that Unilever and Coca–Cola, both their clients, were using facial coding technology in all their advertising testing during 2013. Coca-Cola's 2013 campaign *Let's Go Crazy!* in Latin America used facial coding technology to assess the advertisement's ability to *connect* with the viewer during the developmental phase. Based on the results from early testing, recommendations were given on how to optimise the television advertisement (e.g. connecting emotive scenes with the brand). These led to an increased purchase consideration and consumption of the product ("Building immersive campaigns with Coca-Cola.," 2014).

Sands Research is an American company famous for analysing television advertisements aired during the Super Bowl and assigning a *Neuro-engagement Score*, and for their findings regarding consumer's purchase decisions in-store as part of a project for Point of Purchase Advertising International (POPAI). The advertisement entitled *The Force* – which shows a child dressed as Darth Vader unsuccessfully trying to use *the force* to move objects until he succeeds to start his father's car engine – led to an increase in purchase consideration and contributed to a very successful sales year for the brand (Volkswagen). During the test conducted by Sand's research, it was found that this particular advertisement had the highest neuro-engagement score ever. This has been used as a strong argument in favour of neuromarketing methods for marketing purposes.

In 2012, Innerscope Research conducted a study in which it showed film trailers to more than 1,000 participants. Findings from that study suggested that it was possible to predict box office hits using neuromarketing methods. This, of course, caught the interest of the film industry. Berns & Moore (2012) used neuroimaging to predict the cultural popularity of music. Their findings suggest that neural responses to music could predict purchase decisions and such responses could be generalised and be used to predict cultural popularity.

1.4.3 Self-reported measures of affect

Affect and emotions have been of interest for a long time. A number of scales have been developed and validated to measure arousal and valence, sometimes for measuring mood and other times for measuring the response to stimuli. Some of the scales developed for measuring arousal and valence are:

- The *Positive and Negative Affect Schedule* (PANAS), developed by Watson et al. (1988). This scale consists of 10 items measuring positive and negative affect and is usually used for measuring mood.
- Mehrabian & Russell (1974) developed the *Semantic Differential Scale*. This 18-items scale measures the emotional dimensions of valence (pleasure), arousal and dominance. Each dimension has 6 adjective pairs representing descriptors for each dimension (e.g. happy/unhappy for valence, stimulated/relaxed for arousal).
- The *Affect Grid* developed by Russell et al. (1989) is a single-item scale for measuring both valence and arousal. Subjects are asked to mark or check a square in the 9 x 9 grid. Valence is scored on the horizontal dimension, while arousal is scored on the vertical dimension.
- Bradley & Lang (1994) developed the *Self-Assessment MANIKIN* (SAM) as a way to assess valence, arousal and dominance associated in response to an object or event. It consists of 9-point pictorial Likert-scale for each dimension.

Some criticisms about self-reported measures of affect reported by Shami et al. (2008) are:

- drawing attention to what the experimenter is measuring;
- failing to measure low-intensity emotions; and
- some are not construct valid.

Researchers from marketing, human-computer interaction, decision making, cognitive psychology and many other fields have studied emotions to better understand their role in different cognitive processes and in daily life. Studying emotions have led researchers to better understand how people react or respond to stimuli, how people make decisions, or how people interact with a product or a website. Using self-report scales of affect for this purpose has enabled researchers to quantify affect.

The MANIKIN scale designed by Bradley & Lang (1994) has been widely used in research to measure affect for different purposes like political advertisements (Bradley, Angelini, & Lee, 2007), responses to leader displays (Bucy & Bradley, 2004), emotional reactions in children to pictures (McManis, Bradley, Berg, Cuthbert, & Lang, 2001), affect and attention (Gable & Harmon-Jones, 2010), and emotional perception studies (Costa, Lang, Sabatinelli, Versace, & Bradley, 2010). This is an easy to administer, non-verbal scale to quickly assess arousal and valence, which makes it a useful instrument for experiments that involve people watching a large number of stimuli.

1.4.4 Recall

Recall has been used as a way to measure the impact of emotional stimuli in people. Emotional stimuli are better remembered than neutral stimuli (Buchanan, Etzel, Adolphs, & Tranel, 2006), and this has been demonstrated to be true for pictures (Bradley & Lang, 1994; Bradley, Greenwald, Petry, & Lang, 1992), words (Gomes, Brainerd, & Stein, 2012; Sharot & Phelps, 2004), and sounds (Bradley & Lang, 2000). Emotional arousal is an important moderator of memory enhancement for stimulus manipulations that increase arousal levels (Kensinger & Corkin, 2003).

Emotionally arousing persuasive messages are usually better recalled and perceived as more effective than less emotional messages, both in the fields of health communication and consumer marketing (Dunlop et al., 2008). Recall has also been used and accepted as a valid measure of advertising effectiveness when used in combination with other measures for advertising research (Mehta & Purvis, 2006).

1.5 Summary

Digital interventions to tackle obesity by promoting physical activity have been demonstrated to be effective. Mobile phones have the potential to bridge the gap in health inequalities and reach wider demographics, making

SMS-based interventions of interest for health behaviour change interventions. Favourable results have been found for other behaviours like smoking cessation and binge drinking. Similar favourable results have been found for physical activity interventions.

SMS-based interventions for weight reduction/management and increasing physical activity have positive short-term effects. However, there is still a great deal that we need to understand about the role that the different intervention components (e.g. message tailoring) play and how much they contribute to an intervention effectiveness.

Health communication research theory on personalisation, tailoring and affect has been incorporated in SMS-based interventions, but little is known about its effect on people. Understanding this could potentially inform the development of effective health messages that reach people in a much stronger way at an emotional level, leading to greater intervention effectiveness. Psychophysiological measures can help to understand the role of affect and personalisation of the content of text messages used in mHealth interventions.

Chapter 2:

Thesis aim and objectives

Chapter 2: Thesis aim and objectives

2.1 Why this research?

Against the background of increasing obesity rates, there have been encouraging short-term results of SMS interventions aiming to reduce weight and/or increase physical activity. Text messages should talk in a common language with the receiver, be engaging and persuasive. Communication researchers interested in the persuasive effect of media messages classify them as either rational (cognitive) or emotional (affective) (Nabi, 1999).

There is a body of literature dedicated to the role of emotions and personalisation in health communication and how these can lead to greater intervention effectiveness (Neuhauser & Kreps, 2003). However, the impact of affective communication on individuals has not been objectively measured. Nabi (2014) has suggested that physiological measures could potentially be used to distinguish positive and negative affect.

2.2 Thesis aim and objectives

This research aims to contribute to the development of more effective SMS text messages promoting healthier behaviours through behaviour change interventions by understanding people's response to affective text messages and personalisation using psychophysiology methods. Psychophysiological measurements of electrodermal activity and facial electromyography were used to better understand levels of arousal evoked by the messages and their valence, respectively.

The main objectives of this research were to:

1. Understand the different characteristics of SMS text message interventions that have previously aimed to reduce or maintain weight and increase physical activity.
2. Examine electrodermal activity and facial electromyography as methods to objectively measure arousal and valence associated with text.

3. Measure and compare arousal and valence of previously evaluated affective and cognitive (instrumental) messages using psychophysiology, self-report and recall.
4. Measure the effect of personalisation of affective and cognitive (instrumental) text messages on arousal and valence using psychophysiology, self-report and recall.

2.3 Thesis structure

This thesis has 8 chapters. Chapter 1 served as a brief introduction to this thesis, summarising literature on obesity and physical activity as health behaviours, digital interventions, health communication, tailoring and personalisation, and methods to measure affect. Chapter 2 has presented the aims and objectives of this research.

Chapter 3 presents a systematic review, meta-analysis and meta-regression exploring the role of the different characteristics of SMS-based interventions aimed to reduce/maintain weight loss and promote physical activity.

Chapter 4 introduces the methodology used to collect the data for the three empirical studies conducted as part of this research. Chapter 5 presents the results of a study examining the validity of the psychophysiology methods used in this research. This study used words selected from the Affective Norms for English Words (ANEW) set developed by Bradley & Lang (1999) to manipulate participant’s arousal and valence. A repeated measures design was used to determine electrodermal activity and facial electromyography validity through a correlational analysis between measured electrodermal activity and the corresponding arousal rating – as taken from the ANEW list – and facial electromyography and the valence rating – also taken from the ANEW list.

In Chapter 6 an SMS library of previously evaluated messages taken from the study by Sirriyeh et al. (2010) is assessed using psychophysiology methods. The aim of this study was to identify psychophysiological differences between messages, as affective messages had been reported to be more effective. A repeated measures design was used to examine the differences, if any, between affective and cognitive messages in terms of arousal and valence measured via electrodermal activity, facial electromyography, and self-reported arousal and valence.

Chapter 7 presents the results from study 3, which explored the effect of personalisation – using identification, contextualisation and the combination of both – as a means to enhance the text messages used in Study 2. Again, arousal and valence were measured using electrodermal activity, facial electromyography, and self-report scales of arousal and valence. Affective measures were compared between message manipulation and message type (affective and cognitive).

Finally, Chapter 8 provides a summary of the three studies and its main body is devoted to the general discussion of the research questions, the results of the studies and their contribution to knowledge. Research implications, overall limitations, future directions and conclusions are also presented

Chapter 3:

Systematic review, meta-analysis and meta-regression

Chapter 3: Systematic review, meta-analysis and meta-regression

3.1 Background

Mobile devices provide an easy and cost-effective medium with which to contact people through telephone calls, text messaging, email, etc. More than 460 million mobile phones were sold globally during the first quarter of 2015 (Gartner, 2015). By the end of 2014, there were 89.9 million mobile phone subscriptions in the UK, and a monthly average of 117 SMS and MMS messages per person were sent (Ofcom, 2015a).

Text messages were adopted for health interventions and formally evaluated for the first time in a study by Neville et al. (2002). This study targeted young people with asthma from Tayside, Scotland sending them daily reminders to use an inhaler, health education tips and safety messages. The short message service constitutes a novel method that has the potential to enhance communication and improve healthcare delivery (Krishna & Boren, 2008). Systematic reviews show that the number of interventions researching the use of text messaging for behaviour change interventions has increased with the years (Cole-Lewis & Kershaw, 2010; Fjeldsoe et al., 2009; Free et al., 2013; Hall et al., 2015).

The short message service (SMS or text messaging) is a real-time (synchronous), fast, inexpensive and interactive communication medium that can reach people almost at any time and anywhere. Some of the characteristics that make mobile technologies such a fashionable medium for delivering behaviour change interventions are their popularity, mobility, quick market penetration – even in developing countries – and their ease of use.

The WHO has been a great supporter of mobile technologies and mHealth, especially in developing countries, as these are uniquely positioned to bridge the gaps in health disparities and reach across demographics (Militello et al., 2012). Text messages have been used to communicate with participants by sending different types of health messages, asking participants to self-report behaviour and, sometimes, receive personalised feedback.

The alarming rates at which obesity is growing and the rapid penetration of mobile devices in the market has led to the development of mHealth interventions to tackle this problem. These interventions have typically been designed for weight loss (Carter, Burley, & Cade, 2013; Shapiro et al., 2012), weight loss maintenance (Azar et al., 2013; Kornman et al., 2010), and exercise promotion (Kirwan, Duncan, Vandelanotte, & Mummery, 2012; Mistry, Sweet, Rhodes, & Latimer-Cheung, 2015). Behaviour change theories and techniques have been used for promoting healthier habits by some mHealth interventions.

So far, there has not been a systematic review looking into the effects of the different characteristics of SMS behaviour change interventions (e.g. personalisation) and their contribution to intervention effectiveness. Published systematic reviews of SMS interventions for weight loss and physical activity have mainly focused on intervention efficacy and evidence synthesis (Cole-Lewis & Kershaw, 2010; Connelly et al., 2013; Fanning, Mullen, & Mcauley, 2012; Fjeldsoe et al., 2009; Head et al., 2013; Hutchesson et al., 2015; Liu et al., 2015; Siopis et al., 2014). For this reason, it is important to explore if, how and which SMS intervention characteristics contribute to intervention effectiveness.

3.2 Description of condition

Overweight and obesity are defined as the abnormal or excessive accumulation of fat that may impair health (WHO, 2015a). They have been associated with chronic diseases and costly conditions such as cardiovascular disease, cancer, diabetes (Liu et al., 2015; Vodopivec-Jamsek, de Jongh, Gurol-Urganci, Atun, & Car, 2012) and a higher risk of developing other chronic illnesses and linked to a significant increase in healthcare costs. A raised BMI poses a major risk for non-communicable diseases making it the fifth leading risk factor for global diseases (WHO, 2009).

3.3 Description of the intervention

The ways in which health professionals communicate with patients have evolved throughout the years. The incorporation of communication technologies into our daily life has empowered people to communicate using different media, such as telephone conversations, emails, text messages, and apps.

The main driver of SMS message interventions is generally the content of the messages (Militello et al., 2012). Messages are used to communicate with patients, collect data and send feedback based on patient's data. Communication is restricted 160 characters and can be unidirectional (intervention participant sends a message or receives a message) or bidirectional.

3.4 How the intervention might work

SMS communication requires a sender, a receiver, a message and a common ground over which communication happens – language, culture, behaviour, etc. Interventions using text messages usually rely on a behaviour change theory (e.g. Theory of Planned Behaviour), or a set of behaviour change techniques (e.g. self-monitoring), see Buchholz et al. (2013). An SMS library is normally constructed for this purpose, to communicate with patients/participants. Other intervention characteristics are defined, such as message delivery frequency (dose), directionality and all other tailoring characteristics.

The most important role in these interventions is played by patients. In most cases, they are the message receivers and, sometimes, they provide data so that it may be used to send feedback messages on performance. Patients are the target of the message, and their engagement in the SMS dialogue (when present) is important for the intervention to be successful. Sometimes, interventions make use of additional communication media, such as social media (e.g. Facebook), email, websites or printed material.

Messages serve different purposes, but they are normally used to motivate, give advice, remind people of the targeted behaviour, encourage change, request data or provide feedback. Messages can be personalised or impersonal, or computer-generated.

The aim of this review is to identify and evaluate the most commonly reported characteristics of SMS interventions (see table 3.1) targeting weight and physical activity, and to understand and quantify, where possible, their role in intervention success.

SMS intervention characteristic	Description/Definition
Intervention duration	For how long was the intervention evaluated (in weeks).
SMS 'dose'	How many text messages a participant sent or received (on average) per week.
SMS library development method	How was the library developed (e.g. expert knowledge, focus groups, interviews, participant constructed)
Directionality	Identified as *unidirectional* if participants only either received ('push approach') or sent messages; or *bidirectional* if participants either received a message and had to respond to it or sent a message and received a response ('pull approach')
Communication initiator	Who sends the first message?
Personalisation	If messages sent make use of participant's name, previous responses to other messages, preferences, etc.
Feedback provision	If participants received any type of feedback based on self-reported data (e.g. achievement of goal).
Use of behaviour change theory/technique(s)	Whether a behaviour change theory or technique(s) was (were) used in the design of the intervention. Behaviour change techniques will be identified using Michie et al. (2013, 2014) refined taxonomy of behaviour change techniques.

Table 3.1 Description of intervention characteristics.

3.5 Why is it important to do this review?

Several systematic reviews have been conducted on the use of mobile devices for health promotion evaluating their efficacy (Free et al., 2013; Head et al., 2013; Lau, Lau, Wong, & Ransdell, 2011) or identification, comparison and contrast of features of mHealth interventions (Buhi et al., 2012; Krishna & Boren, 2008). These systematic reviews show that interventions using text messages are mostly effective.

Interventions using SMS as the main delivery method have different characteristics that need to be considered during the design phase. These characteristics were described in section 3.4. The relationship between these characteristics and their contribution to intervention effectiveness remains unclear. This review was therefore conducted to answer this question and propose future directions for research. Appendix B2 shows the PRISMA checklist for this review.

3.6 Aim and objectives

This review was conducted to explore the contribution of the different intervention characteristics to intervention effectiveness. Objectives of this review were to:

1. Determine the effectiveness of interventions using SMS compared to other treatments (e.g. usual care) through a meta-analysis.
2. Through sub-group analyses identify which characteristics are associated with intervention effectiveness.
3. Determine the association of the different intervention characteristics with effectiveness through a meta-regression.

3.7 Methods

3.7.1 Types of studies, intervention and control strategy

This review followed the Cochrane EPOC guidelines. Randomised controlled trials, quasi-randomised controlled trials, before and after studies, pilot studies and interrupted time series studies – with at least three-time points before and after the intervention – were included. Intervention designs included the following cases:

1. Intervention group receiving SMS messages vs. control group not receiving SMS messages (e.g. Haapala et al. 2009).
2. Group 1 receiving one type of message vs. group 2 receiving a different type of message (e.g. Prestwich et al. 2010).

3. Intervention group receiving SMS messages and additional information through other communication media (e.g. Facebook) and/or are part of a programme vs. control group not receiving SMS messages but receiving the same additional information and/or are part of a programme (e.g. Patrick et al. 2009).

3.7.2 Types of participants

All types of study participants not suffering from a long-term condition (other than obesity) were included regardless of age, gender, ethnicity, etc. Studies from any setting were also included, regardless of their healthcare provider.

3.7.3 Types of interventions

Studies included in the review dealt with behaviour change, but were not concerned with managing long-term conditions other than obesity (e.g. diabetes management). SMS text messages had to be the main communication/delivery method. Communication needed to be either between a healthcare organisation, a research group (in person or via an automated system) or a nominated supporter, and the participant. Communication could have been initiated by either part.

Confounded studies (e.g. interventions using more than one communication method in which it was not possible to determine the role or contribution of text messages to the intervention outcome, or in which it was unclear how text messages worked within the intervention) were excluded.

3.7.4 Primary outcomes

The primary outcomes from studies were defined as objective or self-reported measures of weight (change in weight, BMI, BMI-SDS) and/or physical activity (step count, minutes, MET, days).

3.8 Search methods for identification of studies

3.8.1 Electronic searches

The search was restricted to studies published since January 2000 (the first known study using SMS was published in 2002) and was last run on 5th

August 2015. The following databases were used for electronic records searches: Medline, PsychInfo, Global Health, Scopus and Web of Science. Studies published in English could be included.

References from systematic reviews on text messages for weight loss or physical activity, and references from studies to be assessed for eligibility were reviewed for study mining.

Search terms included: (overweight OR obes* OR weight OR weight loss OR physical activity OR exercis*) AND (mobile OR phone OR mobile phone OR smartphone OR cell phone OR cellular phone) AND (text messag* OR text* OR txt OR SMS OR short message service)[2].

3.9 Data collection, meta-analysis and meta-regression

3.9.1 Selection of studies

A total of 788 electronic records were identified through database searches. After removing duplicates, this number dropped to 217; these records were then screened (title and abstract) to assess their potential inclusion in this review. Additionally, 7 studies were identified by reviewing the references lists. A total of 224 electronic records were screened and 159 records were excluded.

The full text for 65 studies was obtained for further eligibility assessment. Of these, 21 were included in this review (see Appendix A1) and the meta-analysis and 44 studies were excluded with reasons (see Appendix A2). Figure 3.1 shows the PRISMA flow diagram for study selection.

[2] Appendix B contains presents the full search strategy for all databases.

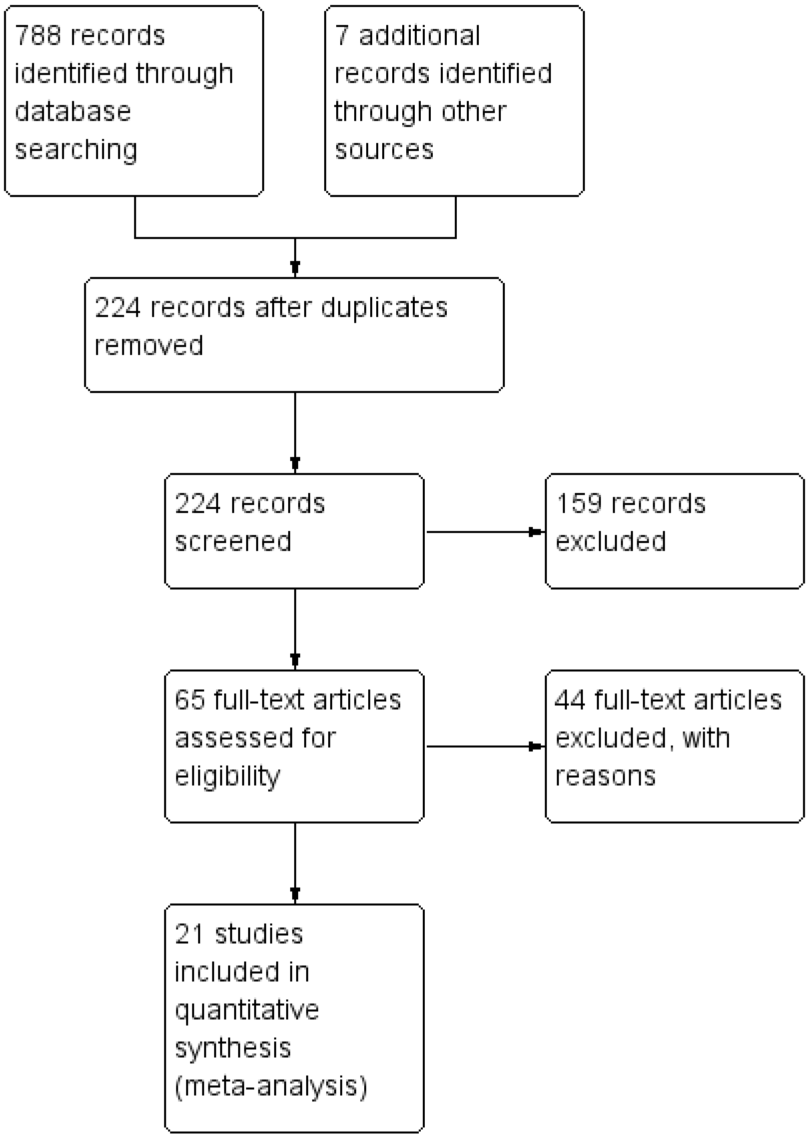

Figure 3.1 PRISMA flow diagram for the selection of eligible studies.

3.9.2 Data extraction

The following data was extracted from the included studies:

1. *General information*: title, authors and year of publication.
2. *Methods*: study design.
3. *Risk of bias*: see section 3.9.4 Risk of bias in included studies.
4. *Participants*: number of participants: health status, age, sex and country.
5. *Intervention*: duration, intervention groups, development of SMS library, SMS dose, directionality (unidirectional or bidirectional), use of personalisation, feedback provision and use of behaviour change theory or techniques (refer to table 3.1 under section 3.4, which provides a brief description of these terms).
6. *Outcomes*: see section 3.7.4 for primary outcomes.
7. *Notes*: Dropout rates.

For studies in which more than one intervention condition existed, the one with the largest effect size was used.

3.9.3 Description of studies

Characteristics of included studies are presented in Appendix A.

Fifteen studies were described by their authors as randomised controlled trials, 2 as quasi-experimental and 4 as randomised pilot studies. Of the 21 studies included in this review, 12 were directed at enabling weight loss or weight loss maintenance, and 9 were directed at increasing physical activity. Eleven studies evaluated the use of SMS for 12 weeks or less, while 10 studies evaluated the use of SMS for more than 12 weeks. Three studies evaluated the use of text messages for a year, Haapala et al. (2009), Shapiro et al. (2012) and Patrick et al. (2013). A study by Nguyen et al. (2013) evaluated SMS as an electronic contact medium for a weight loss maintenance programme for two years.

Only 8 studies reported how the text message library was developed and nearly half of the studies (10) reported the size of the SMS library. Ten studies reported using tailored (personalised) messages, 6 reported not using tailored text messages and 5 did not report whether text messages were personalised or not.

A total of 12 studies reported bi-directional communication, that is, either the researcher or participants sent a message and a message was sent in response. Most studies (15) reported sending messages to participants (push) and 5 studies reported that participants were the ones sending the messages (pull). One study reported that the SMS dialogue could be started by either participants or researchers (Faghanipour, Hajikazemi, Nikpour, Shariatpanahi, & Hosseini, 2013). Only 1 study did not report using a behaviour change theory or techniques (Fassnacht, Ali, Silva, Gonçalves, & Machado, 2015). However, this study is based on the intervention designed by Shapiro et al. (2008), which reported using behaviour change theory.

3.9.4 Risk of bias in included studies

It was considered that the overall risk of bias was low for 8 studies, moderate for 5 and high for 8 studies (see Figure 3.2 for overall risk of bias).

It was considered that allocation concealment was adequate for 11 studies, unclear for 9 and inadequate for 1. Blinding of participants and personnel was assessed as adequate for 8 studies, unclear for 9 and inadequate for 4. It was judged that blinding of outcome assessment was adequate for 16 studies, unclear for 4 and inadequate for only 1 (see Figure 3.3, risk of bias summary).

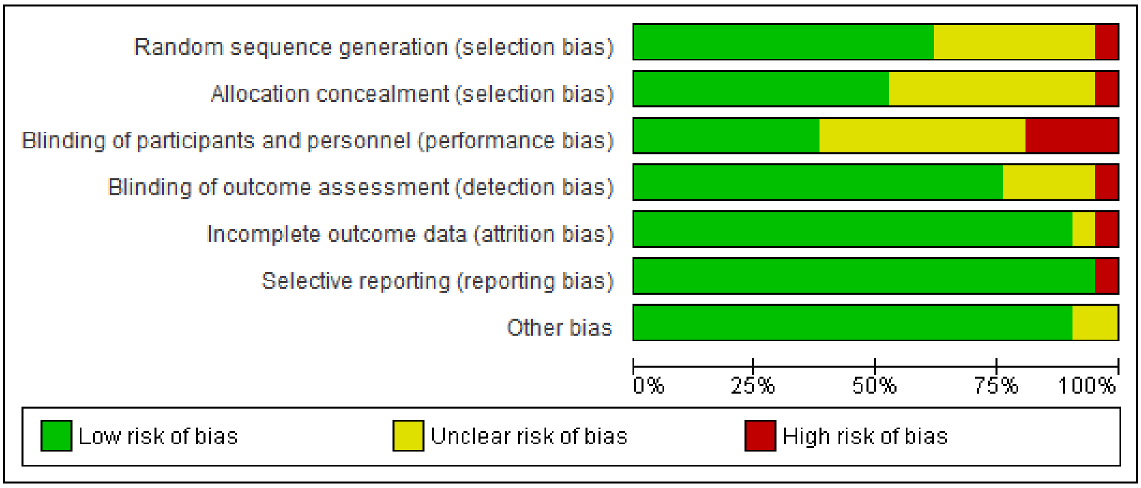

Figure 3.2 Cochrane risk of bias graph.

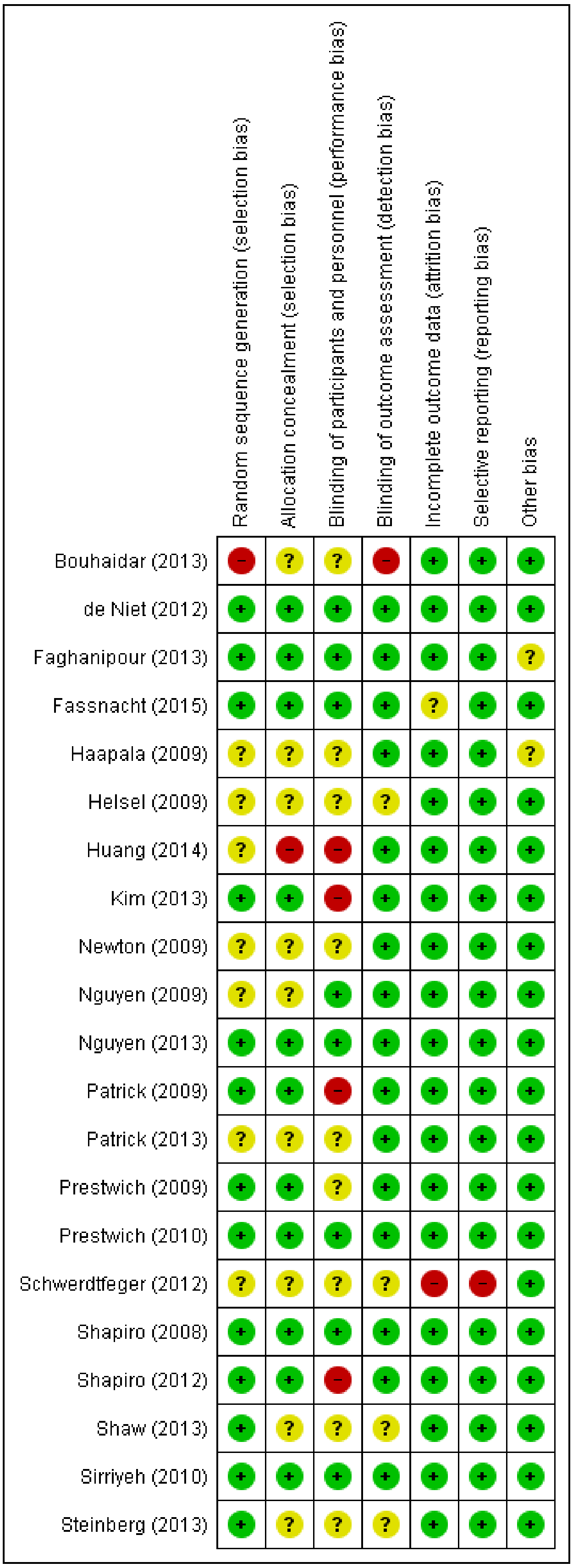

Figure 3.3 Cochrane risk of bias summary.

3.9.5 Funnel plot

A funnel plot was used to assess the likelihood of reporting bias, looking for asymmetry. The funnel plot (Figure 3.5) showed little evidence of publication bias for the effectiveness of SMS interventions, as this plot is somewhat symmetrical.

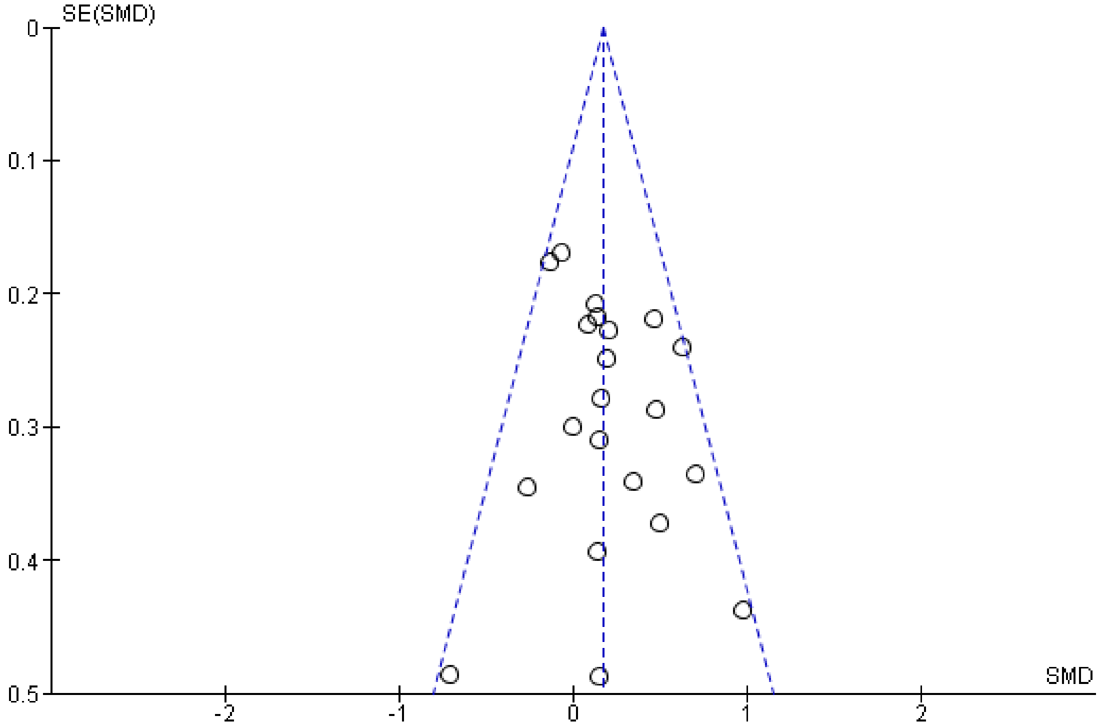

Figure 3.4 Funnel plot.

3.9.6 Heterogeneity

Heterogeneity was examined for the effect sizes of intervention efficacy using Higgins I^2. The statistical test showed that heterogeneity is probably not important, I^2 = 16%, for which χ^2 (20) = 23.92, p = 0.25. According to the Cochrane Handbook for Systematic Reviews of Interventions (Higgins & Green, 2011), a value of I^2 between 0% and 40% might not be important for heterogeneity. Based on these values it can be assumed that effect sizes are somewhat homogeneous.

3.9.7 Efficacy of intervention

Standardised mean differences with random effects were used to calculate the overall effect size; this effect size was *g* = 0.18 [0.06, 0.31], *p* = 0.004. This effect size favours interventions using SMS (see Figure 3.5).

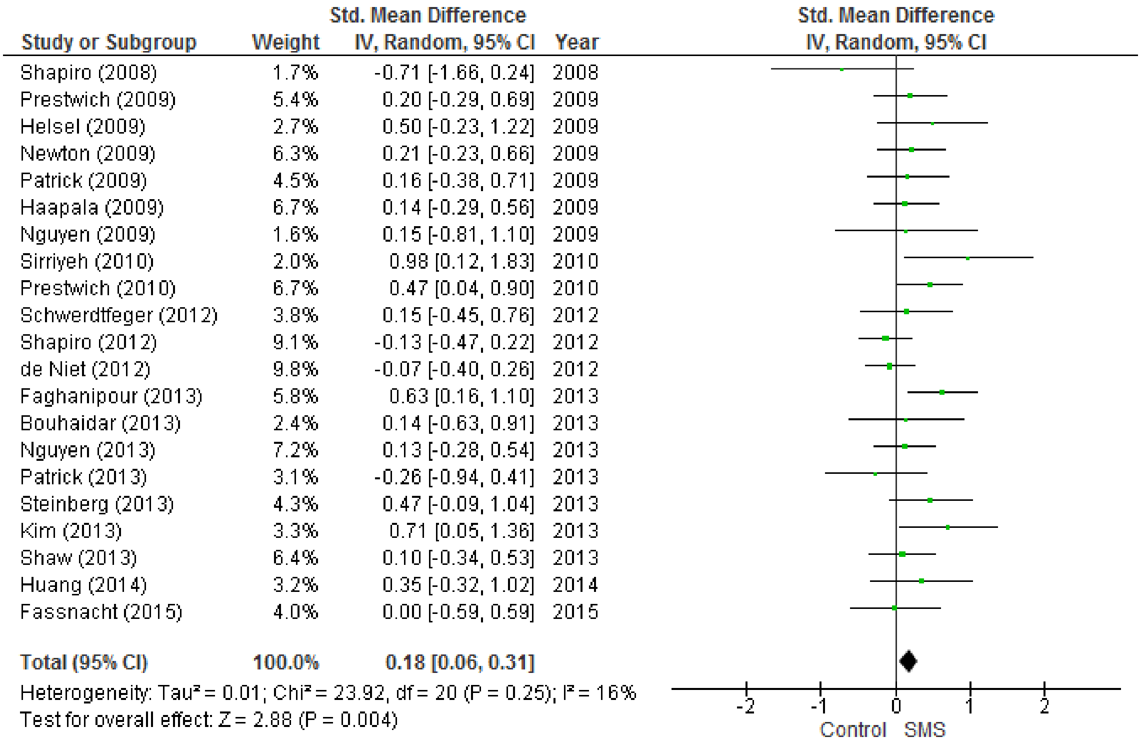

Figure 3.5 Forest plot of SMD effect sizes and 95% confidence intervals representing the effect of SMS interventions for weight and physical activity.

3.9.8 Summary of findings

Summary of findings for short message interventions targeting weight loss/maintenance and physical activity are presented in Figure 3.6. A total of 8 studies targeting physical activity were included. The quality of the evidence was assessed using GRADE and was found to be moderate. For weight loss/maintenance interventions were included 13 studies and the quality of the evidence was found to be high.

Short message service interventions for reducing weight/increasing levels of physical activity

Patient or population: All types of patients not suffering from a long-term condition (other than overweight or obesity)
Settings: Any
Interventions: 1) Short message service vs control (no SMS); 2) SMS type 1 vs SMS type 2; 3) SMS + additional communication media vs additional communicational media

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk **Control**	Corresponding risk **SMS interventions**				
Physical Activity Follow-up: 2 - 24 weeks		The mean physical activity in the intervention groups was **0.28 standard deviations higher** (0.02 to 0.54 higher)		376 (8 studies)	⊕⊕⊕⊖ **moderate**[1]	SMD 0.28 (0.02 to 0.54)
Weight Follow-up: 2 - 104 weeks		The mean weight in the intervention groups was **0.13 standard deviations higher** (0.01 lower to 0.26 higher)		871 (13 studies)	⊕⊕⊕⊕ **high**	SMD 0.13 (-0.01 to 0.26)

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Total population size is less than 400.

Figure 3.6 Summary of findings for SMS interventions targeting weight loss/maintenance and physical activity.

3.9.9 Subgroup analyses

Subgroup analyses were performed for the intervention moderators. Three sensitivity analyses were first performed to determine the influence on the effect size of randomised controlled trials, studies with high risk of bias and studies with large samples. Firstly, only randomised control trials were included and the same effect size was found, $g = 0.18$ (95% CI = 0.04, 0.32). The overall effect was Z = 2.58, $p = 0.01$. Heterogeneity was low in this case, $I^2 = 16\%$, with the statistical test showing that χ^2 (14) = 16.60, $p = 0.28$.

When studies with only low and moderate risk of bias were included, the results were very similar, with an effect size of $g = 0.19$ (95% CI = 0.02, 0.37), the overall effect was Z = 2.16, $p = 0.03$. Heterogeneity was greater at $I^2 = 31\%$, $X^2(12) = 17.4$, $p = 0.14$.

All studies had very similar sample sizes, *M* = 29.9, *SD* = 17.7. For this reason, exclusion of large studies for the sensitivity analysis was not performed.

Subgroup analyses were also performed to explore the association with the different intervention characteristics. Firstly, interventions targeting behaviour (weight and physical activity) were compared. No significant differences were found for this comparison, $X^2(1) = 1.11$, $p = 0.29$.

Subgroup differences for the use of tailored messages and providing feedback also found no statistical significance, $X^2(1) = 0.34$, $p = 0.56$, and $X^2(1) = 1.96$, $p = 0.16$, respectively.

Finally, the subgroup analysis for directionality also failed to find statistically significant differences between unidirectional and bi-directional interventions, $X^2(1) = 3.44$, $p = 0.06$.

3.9.10 Meta-regression

Meta-regression for intervention duration and effect size, and SMS dose and effect size were performed. The meta-regression for intervention duration and intervention effectiveness showed that with time, as expected, the effect size declines, $\beta = 0.99$, SE = 0.005, $t(19) = -2.263$, $p = 0.017$, CI 95% [0.98, 1] (see Figure 3.7). The size of the circles represents the size or weight of the studies.

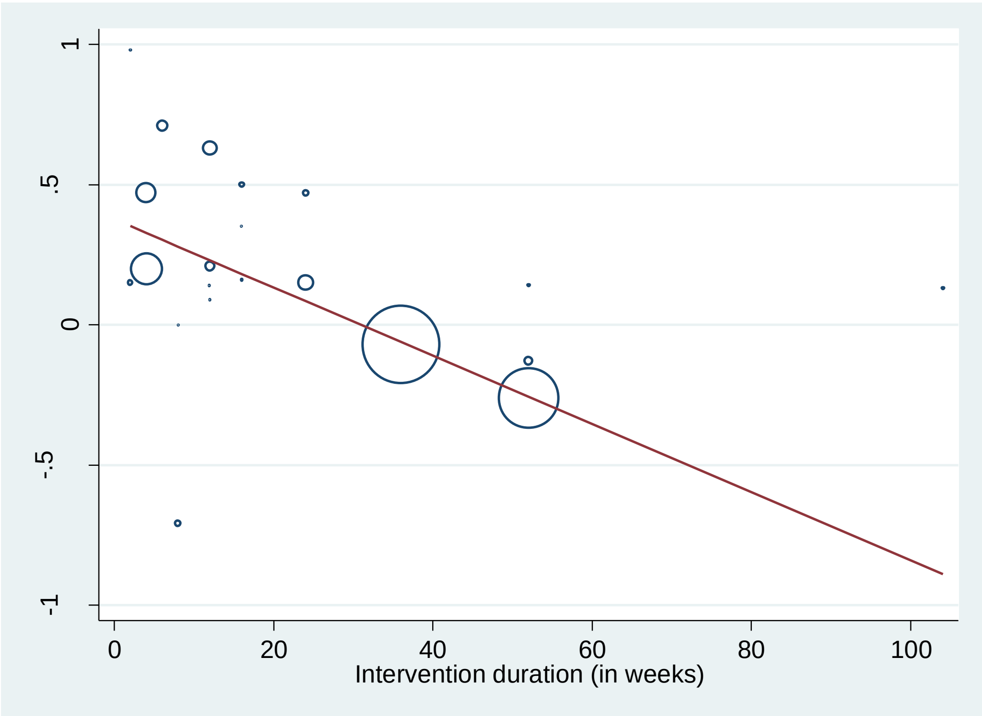

Figure 3.7 Meta-regression of intervention duration and effect size, showing that effect size declines with time.

The meta-regression for SMS dose and effect size showed an increase in effect size as the SMS dose increases. This, however, was not statistically significant, $\beta = 1.03$, SE = 0.03, $t(19) = 1$, $p = 0.33$, CI 95% [0.97, 1.1] (see Figure 3.8 below). The size of the circles represents the size or weight of the studies.

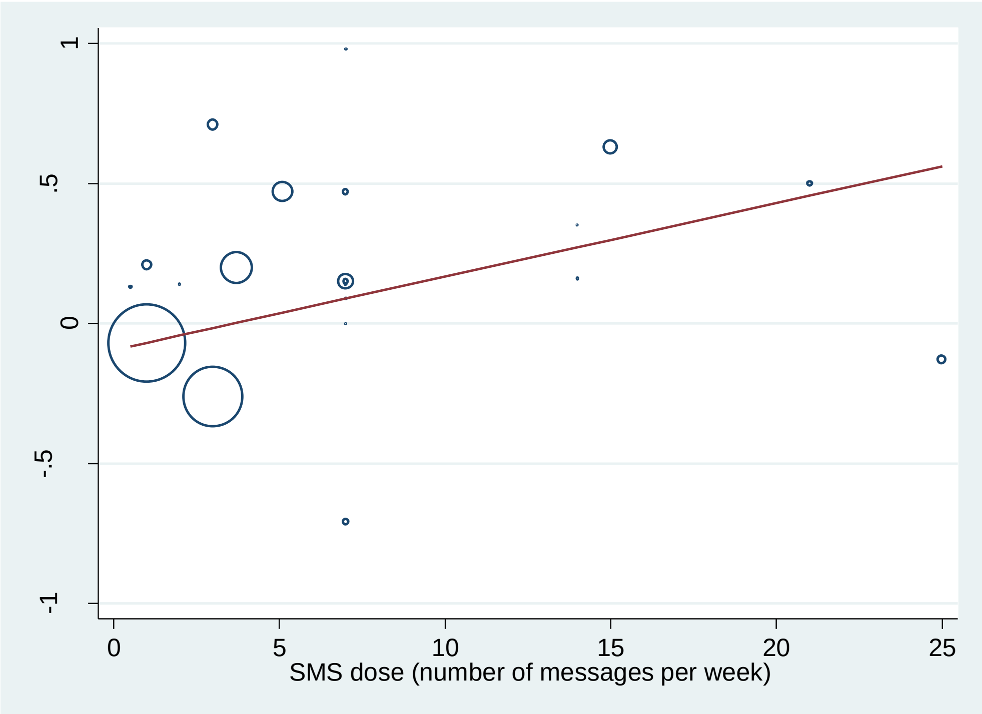

Figure 3.8 Association between SMS dose and effect size showing no association between them.

3.10 Discussion

3.10.1 Summary of main results

The purpose of this systematic review was to estimate the contribution of the different intervention characteristics to intervention effectiveness. Different objectives were defined to answer this question. The first objective was to determine how effective SMS-based intervention for weight and physical activity were, compared to other treatments. The meta-analysis found that SMS-based interventions were more effective when compared to other treatments (e.g. usual care). A statistically significant effect size (g = 0.18, $p < 0.01$) was found.

Other systematic reviews have also favoured SMS text messages as an effective means for health promotion (Hall et al., 2015; Head et al., 2013; Preston et al., 2011), health behaviour change or disease management (Fjeldsoe et al., 2009; Free et al., 2013), behaviour change in disease prevention and management (Cole-Lewis & Kershaw, 2010), weight loss (Siopis et al., 2014) and physical activity (Buchholz et al., 2013).

Digital interventions, such as SMS-based interventions, are designed around different intervention characteristics. The second objective of this review was to examine several of these characteristics (see Table 3.1) to assess how much they moderated intervention effectiveness. Studies were coded for their methods, participants, intervention and outcome characteristics. Methodological and participant subgroup analyses showed no significant moderation of intervention effectiveness. The different intervention characteristics were then analysed.

Subgroup analysis showed no difference in effectiveness between interventions personalising messages (tailoring) and interventions not personalising messages. The same was true for interventions providing feedback and not providing feedback. The literature supports the idea that personalising and tailoring messages increases intervention effectiveness (Bull, Holt, Kreuter, Clark, & Scharff, 2001; Head et al., 2013; Jensen, King, Carcioppolo, & Davis, 2012; Noar, Benac, & Harris, 2007). However, the meta-analyses that found significant differences for personalised interventions were not specific for weight-related behaviours. This may be because of insufficient power to detect small differences.

When comparing effect sizes for unidirectional and bidirectional interventions, no difference between groups was found.

This meta-regression found that the intervention effect size declines with time. Most of what is known about the effectiveness of psychological interventions for physical activity is for interventions lasting less than six months (Uphill, 2014).

The meta-analysis by Head et al. (2013) and Orr & King (2015) found a significantly greater effect for interventions sending multiple daily SMS. The meta-regression in this review found no statistically significant association between SMS dose and effect size, although there was a trend in that direction.

3.10.2 Limitations and future research

This review needs to be considered with caution as there are a number of important limitations. First, only studies in English were eligible for inclusion, which could have excluded relevant publications in other languages due to a lack of a translation.

Seven studies, mostly about physical activity (Fassnacht et al., 2015; Kim & Glanz, 2013; Prestwich, Perugini, & Hurling, 2009; Prestwich et al., 2010; Shapiro et al., 2008; Shaw, Bosworth, Hess, et al., 2013; Sirriyeh et al., 2010) relied on self-reported data. Studies directed to enabling weight did not use self-reported measures.

Randomised controlled trials and less rigorous designs (pilot studies and quasi-experimental) were included in this review. However, the number of participants in all these studies was very similar, and omitting pilot studies and quasi-experimental studies did not alter results. Some studies included in this review (de Niet et al., 2012; Nguyen et al., 2013) were concerned with behaviour change maintenance and not just behaviour change. Studies focusing on both physical activity and weight loss were included to maximise the number of SMS-based interventions for the meta-regression and meta-analysis. Even so, power was small and insufficient to show small effect sizes.

More research is needed to better understand the effectiveness of these interventions and how their different characteristics interact and contribute to intervention effectiveness. Intervention characteristics, such as the content of the text messages, may contribute to intervention engagement and should be further studied. There is a need for studies with larger samples and of a longer duration; most studies have small samples and are, on average, only 12 weeks long.

Digital interventions, such as mHealth interventions, are part of a growing and fast-changing field that is still in its infancy (Head et al., 2013; Noar & Harrington, 2012). Systematic reviews and meta-analysis need to be frequently updated to have a better understanding of how these interventions and their characteristics interact and contribute to intervention effectiveness and engagement. Emerging digital health interventions for these same behaviours using other text messaging protocols, such as instant messaging applications like WhatsApp (Muntaner-Mas, Vidal-Conti, Borras, Ortega, & Palou, 2015), Facebook Messenger or Hangouts, could potentially have similar intervention characteristics like SMS-based interventions (e.g. contact dose) and should be explored. These new technologies could inform future systematic reviews, meta-analyses and meta-regressions to understand intervention utility and the contribution of the different intervention characteristics to effectiveness.

Chapter 4:

General methodology

Chapter 4: General methodology

4.1 Overview

This chapter outlines the general methodological approach taken in the research primary studies shaping this thesis. An overview of the participants, recruitment, ethical considerations, materials and equipment, general experimental procedure, data management and signal filtering are summarised here. Details specific to individual studies will be provided as part of the methods section in each of the 3 experimental chapters.

4.2 Participants

4.2.1 Sample

A convenience sample of 40 participants was used for each of the studies conducted in this thesis. Because there are no available power calculations for electrodermal activity or facial electromyography to calculate the sample size, the number of participants used in the studies was based on research that recorded the same biosignals (Bolls et al., 2001; Larsen et al., 2003; Nikula, Klinger, & Larson-Gutman, 1993; Norris, Larsen, & Cacioppo, 2007; Radin, 2004). Tests conducted at the Institute of Psychological Sciences' Psychophysiology Laboratory have shown that a sample size of 40 participants is sufficiently reliable to detect significant differences using psychophysiological measures.

4.2.2 Inclusion and exclusion criteria

Inclusion criteria. Healthy males and females between 18 – 45 years of age and likely to be physically active. It has been found that people of 40 – 45 are less physically active than younger people (Doll-Tepper, Dahms, Doll, & von Selzam, 1990), and that cardiorespiratory fitness declines after 45 years of age (Jackson, Sui, Hébert, Church, & Blair, 2009).

Exclusion criteria. Potential participants were excluded if:

- Not having a good command of English. When English was not their native language, participants must have lived for at least an academic year in an English speaking country and feel comfortable with the language

- Visually impaired (the use of corrective lenses was acceptable).
- Suffering from diabetes, anxiety, panic attacks or any chronic neurological disorder such as, but not limited to, epilepsy, Parkinson's disease or tremors.
- Being under certain medications such as muscle relaxants, anticholinergics or blood pressure medication.
- Skin allergies or sensitivity to any of the ingredients of the electrode gel.

4.2.3 Recruitment

Participants were recruited through posters and flyers (see Appendix C) posted throughout the University of Leeds. Students of the University's Faculty of Medicine and Health were emailed information about the study, the participant information sheet for the studies (see Appendix D) and contact details. Staff, students, alumni of the University of Leeds and their referees (friends and family), could take part in the experiments.

Potential participants contacted the researcher through either the telephone or by email. Contact details were provided in posters, flyers and emails sent.

After initial contact, a participant information sheet was sent to provide more detailed information on what the experiments were about, how they were going to be conducted and what participants were expected to do. This gave potential participants the opportunity to make an informed decision on whether to take part in the research or not. A one-week period was given to consider participation.

After agreeing to take part in the study, participants were provided with available days and times to take part in the experiment. They selected the most convenient day and time for them. In return for their time and as an incentive, participants were offered £7 upon completion of the experiment.

4.3 Ethical considerations

4.3.1 Ethical approval

Ethical approval was granted for the experiments through the Institute of Psychological Sciences Research Ethics Committee (IPSREC). Studies followed the ethics guidelines defined by the British Psychological Society (BPS).

4.3.2 Risks and right to withdraw

A very little physical risk is associated with recording electrodermal activity and facial electromyography, or looking at a computer screen for short periods of time. The psychophysiology laboratory's standard operating procedure (SOP 14-0012) served as a guideline to designing the experiments and recording biosignals.

The main risk was posed by the use of cleansing towels, and the electrode gel for electrodermal activity and facial electromyography. These gels occasionally cause skin irritation or allergic reactions. Participants were asked about any skin allergies or sensitivity to any of the ingredients of the electrode gel before providing them with cleansing towels and attaching the electrodes.

The Biopac acquisition unit (MP35) used for recording the biosignals is widely used for research purposes. The MP36/35/45 satisfies the Medical Safety Test Standards affiliated with IEC60601-1. The MP36/35/45 is designated as Class I[3] Type BF[4] medical equipment (Biopac Systems Inc., 2015a). The analog input channels are isolated human-safe universal input amplifiers. As an additional precaution measure, a circuit breaker was added.

The stimuli material read by participants were not thought likely to cause offence/distress for any of the studies. Stimuli for study 1 consisted of words taken from a validated list of English words (ANEW), while text messages promoting physical activity were used as stimuli for studies 2 and 3.

[3] Class I means that the equipment has a protective earth.
[4] Generally used for devices that have medium or long term conductive contact with patients.

Participants had the right to withdraw from the experiment at any time and without giving any reason. No participant in any of the three experiments withdrew their participation.

4.3.3 Informed consent

Informed consent was sought before any experimental procedure took place (see Appendix E). Participants were emailed a participant information sheet which briefly described the experiment, the task (reading – study 1 – and rating text messages – studies 2 and 3), the electrodes to be used and electrode positioning before any arrangements were made for them to visit the psychophysiology laboratory. Questions and/or concerns regarding the experiment, the task and/or the electrodes were addressed either via email, telephone or in person.

4.3.4 Confidentiality and anonymity

Participants' information and data were kept confidential. All data were anonymised using a participant identification number assigned from the initial sign up to the study. This identification number was the only identifier stored with each participant's data. The file linking participant's identification number and personal data was password protected, encrypted, securely stored in a university computer and separated from the experimental data. Only the researcher had access to hard and soft data.

4.3.5 Data collection and storage

Hard study data (questionnaires and forms) was stored in a filing cabinet only accessible to the researcher in the PhD office of the Charles Thackrah Building (G.02). Consent forms with names/initials were stored in a filing cabinet in the psychophysiology laboratory of the Institute of Psychological Sciences (LG.27), being entirely separated from all other information.

Anonymised soft data (biosignal recordings and data extracted from the biosignal recording files) were password protected and encrypted. Data were securely stored in a password protected university computer.

4.4 Materials and equipment

4.4.1 Participant data collection

All three studies collected participant's basic health information through a simple paper form (see Appendix F). Demographic information was also collected and was used to assess participant eligibility. Information on handedness was collected to inform the electrodermal activity electrode placement position. The tasks performed during the experiments involved participants using the computer keyboard. Therefore, a non-dominant hand electrode positioning protocol was used. This allowed the participants' dominant hand to make use of the computer keyboard.

The self-perception and eating behaviours questionnaire (see Appendix G) was used in the three studies. This questionnaire collected information on self-reported weight, height, exercise, self-perception and dieting status.

4.4.2 The psychophysiology laboratory

The psychophysiology laboratory was located in the Institute of Psychological Sciences of the University of Leeds. It is a well-lit, neutral and quiet space. The room temperature is always between 22ºC and 26ºC, which lies within the thermoneutral zone for experimental conditions using electrodermal activity in a laboratory, as suggested by Venables & Christine (1973).

There are two desks in this room. The experimental desk is used by participants, while the recording and monitoring desk is used by the researcher. Over the participant's desk sits the computer monitor and keyboard, as well as the Biopac MP35 unit. The other desk, which is designated for the researcher, holds two computer screens on the desk. The first screen allows the researcher to observe the biosignal acquisition waves in real time, while the second screen serves as a mirror of the participant's monitor. This allows the researcher to follow, unobtrusively, what the participant is watching.

Participants sat with their back to the door and, from their position, they could neither see the researcher nor the screens on the researcher's desk. This allowed participants to concentrate only on the screen in front of them and the experimental task. No other distractions were in their range of sight.

4.4.3 Software

Software to present stimuli under a precise timing was needed, therefore E-Prime 2.0 software (Psychology Software Tools Inc, 2012) was used on the experimental PC for stimuli presentation. Biosignals were acquired and recorded using Biopac Student Lab 4.0.0 (Biopac Systems Inc., 2012).

4.4.4 Hardware

PC characteristics

Two Dell Optiplex 760 running on Microsoft 7 Enterprise 64-bit Service Pack 1 (Intel® Core Duo™ CPU E7400 @ 2.8 GHz processor, 2 GB RAM, 150 GB HDD) PCs were used to run E-Prime 2.0 and the Biopac Student Lab 4.0.0. Three 16” Dell monitors with a screen resolution of 1027 x 768 and a 60 Hz refresh rate were used. One monitor was in the experimental desk, where stimuli were displayed, and two in the recording and monitoring desk.

MP35 acquisition unit

The Biopac MP35 acquisition unit was used for biosignal acquisition and recording. This is a four-channel data acquisition system consisting of four analog input channels and a USB port to communicate with the PC.

Electrodermal activity transducer

The SS3LA electrodermal activity transducer with reusable electrodes was used to record exosomatic electrodermal activity. This transducer consists of two silver-silver chloride (Ag/AgCl), non-polarisable electrodermal activity electrodes with a contact area of 6-mm diameter. The SS3LA electrodes are shielded to minimise noise interference and improve recordings. They operate by applying a fixed voltage of 0.5 V direct current across both electrodes, detecting the current flow between them. They were attached to the distal phalanges of the participant’s non-dominant hand using stretchable Velcro® straps. Isotonic, hyposaturated, conductant GEL101 is used to fill the 1.6 mm cavity of the electrodes (Biopac Systems Inc., 2015c).

EL254S electrode and SS1LA transducer for facial electromyography

EL254S electrodes were used for recording facial electromyography. These are reusable silver-silver chloride (Ag/AgCl), non-polarisable electrodes with a contact area of 4-mm. Electrode gel GEL100, which is non-irritating and hypoallergenic, was used as a conductant with these electrodes (Biopac Systems Inc., 2015b). ADD204 double-sided adhesive disks and M3™ micropore tape was used to hold the electrodes in place.

The SS1LA shielded electrode adapter was used to connect the EL254S electrodes to the MP35 acquisition unit.

Facial electromyography electrodes were applied over corrugator supercilii and zygomaticus major muscles on the left side of the participant's face (Fridlund & Cacioppo, 1986; Rozga et al., 2013; Zhou & Hu, 2004). Special care was taken while applying the electrodes over sites that were dry and free of excessive hair, not over scar tissue, areas with established erythema or lesions of any kind, according to the manufacturer's recommendations (Biopac Systems Inc., 2015b).

4.4.5 Configuration

MP35 acquisition unit

The sampling rate was set at 2000 samples/second with an acquisition length of 3600 seconds.

Electrodermal activity channel configuration

Channel 4 was used to record exosomatic electrodermal activity. This channel was configured using the EDA (0 – 35 Hz) preset and a gain of x2000, following manufacturer's usage recommendations (Biopac Systems Inc., 2015a).

Facial electromyography channels configuration

Channels 1 and 2 were dedicated to facial electromyography data acquisition. Channel 1 was used to record muscle activity over corrugator supercilii (CS) and channel 2 recorded muscle activity over zygomaticus major (ZM). Both channels had a digital high-pass filter of 10 Hz and a digital low pass of 500 Hz (van Boxtel, 2010) applied, with a high pass filter of 5Hz and a gain of x5000 (Biopac Systems Inc., 2003).

4.5 Experimental procedure

4.5.1 Before the session

After potential participants agreed to take part in the study an email confirming their appointment date and time was sent. Participants were asked to refrain from drinking caffeine (Boucsein, 2012; Davidson & Smith, 1991) three hours before and during the experiment.

4.5.2 During the session

On the day of their appointment participants met the researcher in the foyer of the Institute of Psychological Sciences. Participants were escorted and introduced to the psychophysiology laboratory. The researcher reminded participants what the study was about and asked them if they had any questions or concerns. In case there were any questions or concerns, a copy of the participant information sheet for each experiment was always available in the psychophysiology laboratory for participants to re-read or refer to. In case there were any questions, these were answered to participant’s satisfaction.

Next, consent forms were presented to the participants to be signed (see Appendix E). After the consent form was signed the researcher reminded participants that they could withdraw at any time and without giving any reason to do so; any data collected would be immediately destroyed.

A second form collected the demographic information of participants, handedness and other health-related information (see Appendix F).

Participants were then briefed on where the electrodes were going to be placed, how it was going to be done and which sites needed to be cleansed and how. Following, they were asked to wash their hand and were shown where the toilet was. While participants were washing their hands the researcher would fill the electrodermal activity and facial electromyography electrodes with gel.

Back in the laboratory, participants were given a cleansing towel to clean their face, asking them to put particular attention to the left side of the face over corrugator supercilii and zygomaticus major sites. Participants were asked to remove any jewellery from their fingers and wrists. A transparent basket was available for them to place their jewellery; it remained in their sight at all times.

Participants sat in a comfortable position facing the computer screen. First, the electrodermal activity electrodes were attached on the non-dominant hand (see Figure 4.1) over the distal phalanx of the index and middle finger (Boucsein, 2012; Scerbo, Freedman, Raine, Dawson, & Venables, 1992). This allowed participants to use their dominant hand to use the computer keyboard during the experiments.

Figure 4.1 Electrodermal activity electrodes attached over the distal phalanx of the index and middle finger.

Finally, the facial electromyography electrodes were attached (see Figure 4.2), beginning with the electrodes to be attached over the corrugator supercilii muscle, which is directly above the left eyebrow on an imaginary vertical line traversing the endocanthion[5]. To locate this muscle, the researcher asked participants to frown to attach the negative lead. The positive lead was attached approximately 1 cm to the right and slightly higher. Micropore tape was used to hold the electrodes and reduce cable movement during the experiment, as this could translate in artifacts.

[5] The point at which the inner end of the upper and lower eyelid meets.

Finally, the electrodes over zygomaticus major were attached. To accurately locate the muscle, participants were asked to smile. The negative lead was placed midway along the imaginary line joining the cheilion[6] and the preauricular depression[7]. Again, Micropore tape was used to hold the electrodes in place and reduce cable movements (Biopac Systems Inc., 2003; Fridlund & Cacioppo, 1986).

Figure 4.2 Facial electromyography electrodes attached over corrugator supercilii and zygomaticus major.

During the electrode placement the researcher explained the task to be performed during the experiment – read words and press a key when a nonsense word appeared (study 1), or read text messages on screen and rate them using the SAM scales for arousal and valence developed by Bradley & Lang (1994) (study 2 and 3), and rate the messages for engagement (study 3).

Once all the electrodes were in place participants were asked if they were reasonably comfortable with the setup. Electrodes were visually inspected to make sure they were still in the correct position. The computer screen on the participant's desk was switched on and the message "`Welcome to the Psychophysiology Laboratory!`" was displayed. Participants' distance to the computer screen was between 70-cm to 90-cm so that they could easily read the text displayed on the screen. Adjustments were made if this

[6] The most lateral point at the corner of the lips.
[7] The bony dimple above the posterior edge of the cheek bone.

was not the case to ensure participants were able to read the text on the screen and were comfortably seated.

Electrodes were tested before the experiment began to verify they were accurately capturing and recording biosignals. Abnormal waves prompted the researcher to check the electrodes' positioning. Firstly, participants were asked to frown and raise their eyebrows to verify that the electrodes over corrugator supercilii showed muscle activation. Next, they were asked to smile, and activity over zygomaticus major should be observed. Lastly, participants were instructed to take a deep breath and hold the air for a couple of seconds before exhaling. Electrodermal activity onset should be observed. If no activity was observed, participants were asked to cough, instead, to observe electrodermal activity.

Participants were informed that a 5-minute baseline was to be recorded. They were instructed not close their eyes (blinking was allowed) during this time, try to be as relaxed as possible and avoid moving as much as possible during this period. After the baseline recording, participants followed the instructions on the computer screen.

The spacebar key on the keyboard allowed participants to move between screens; this was disabled for screens where there was a fixed waiting time (e.g. the baseline recording), screens automatically changed. Before the experiment began the researcher asked participants if they had any questions. Once participants felt ready to begin they were instructed to press the space bar key to begin the experiment.

4.5.3 The experiment

The following text presents the general instructions that were given to the participants:

Welcome screen

    Welcome to the Psychophysiology Laboratory!

Instructions screen 1

    Welcome! The experiment is about to begin.

Please avoid moving as much as possible while the experiment is running.

<<Press SPACE move to the next screen>>

Baseline recording screen

Please relax. This is a 5-minute period to allow you to adjust to the laboratory environment before proceeding with the experiment.

After this screen, experiment specific screens followed. Details of the instructions specific to individual studies are presented in the methods section of each experimental chapter.

End of experiment screen

End of experiment

4.5.4 Dealing with artifacts

If there were any events that could translate into artifacts (e.g. coughing, sneezing, movement) a note of the type of event and the time, as it appeared in the Biopac recording session, was made. During the data extraction process, these notes were used to review and exclude the stimulus and its corresponding recording, if necessary.

4.5.5 After the experiment

At the end of the experiment, participants were asked how they felt, followed by an electrode check to ensure they were still capturing muscle movement and skin conductivity. Participants were asked to frown and then raise their eyebrows one last time to observe activity over corrugator supercilii. Participants smiled to verify that there was still activity over zygomaticus major. And, lastly, the researcher asked participants to take a deep breath, hold the air for a couple of seconds before exhaling so that electrodermal activity could be observed. Sometimes they were asked cough if no electrodermal activity was visible by taking a deep breath.

The session was saved in the laboratory’s computer hard drive as an .acq file using the participant’s identification number as the file name, and under the appropriate folder.

The researcher turned off the participant's screen and explained that the experimental part of the session had ended. However, a couple procedures still needed to be completed before the session ended.

4.5.6 Electrode removal

After the experiment ended electrodes were removed. The electrode removal process was explained to participants before removing any of the electrodes.

Participants were given the option to remove themselves the electrodermal activity electrode by removing the Velcro strips. Due to the frailty of the facial electromyography electrodes, these were removed by the researcher.

After all electrodes were removed, a new cleansing towel and a mirror were provided so that participants could remove any traces of gel from their face and fingers.

4.5.7 Questionnaire, participant debrief, payment and goodbye

The self-perception and eating behaviours questionnaire was handed to participants to complete (see appendix G). After completing this questionnaire, participants for studies 2 and 3 were, in addition, asked to write down as many messages as they could remember. Once participants stopped writing for an interval of 15-20 seconds they were asked to stop. No more than 5 minutes were given to complete this task.

Once finished, participants were thanked for their time and were given £7 as compensation for their time and participation. A debrief sheet (see Appendix H) was handed to participants. Questions regarding the experiment and the task were asked if there were any.

Participants were reminded to take any jewellery removed and all their personal belongings before leaving the lab. The researcher showed participants to the exit and thanked them again for their time. This concluded the session.

4.5.8 After the session

Micropore® tape from the facial electromyography electrodes was disposed into a special bin for biomedical waste. Electrodermal activity and facial electromyography electrodes were cleaned using cold water and cotton swabs after use following product storing and cleansing recommendations by Biopac Systems Inc. (2015c).

The consent form, demographic information and questionnaires were filed in the appropriate folders and cabinets. Documents to be filed outside the laboratory were stored in a box file before being removed from the lab.

4.5.9 Data management and filtering

Post-acquisition psychophysiology data was cleaned and filtered following guidelines and common research practice. Electrodermal activity was subjected to an infinite impulse response low pass filter of 10-Hz to eliminate noise and artifacts, and then square root transformed to correct the positive skewness inherent to skin conductance data (Boucsein, 2012; Norris et al., 2007; Silvestrini & Gendolla, 2007).

Facial electromyography data was subjected to a 15-Hz infinite impulse response high pass filter to reduce movement and blink-related artifacts, then rectified (using 25 samples), and, finally, square root transformed to correct for positive skewness inherent to EMG data (Fridlund & Cacioppo, 1986; Larsen et al., 2003).

Communication between E-Prime and Biopac allowed Biopac, through a digital channel, to time stamp when a stimulus was on-screen and whenever this went off-screen. The use of this digital channel and the time stamps allowed the researcher to extract the data for calculating reactivities.

Electrodermal and facial electromyography reactivities were calculated as the difference between the mean activity during the 6000-ms stimulus on-screen period and the 1000-ms immediately prior to stimulus onset (Lang, Greenwald, Bradley, & Hamm, 1993; Larsen et al., 2003; Norris et al., 2007; Wolf et al., 2005). Electrodermal activity was split into early EDA (the first 3000-ms after stimulus onset) and late EDA (the last 3000-ms of stimulus onset)

4.5.10 Statistical analysis

Electrodermal reactivity and facial electromyography reactivity were transformed to standardised z-scores for better inter-individual comparability (Boucsein, 2012; Bush, Hess, & Wolford, 1993) using the formula: $z = \frac{x-\mu}{\sigma}$, where μ is participant's mean reactivity and σ is participant's reactivity standard deviation. Previous work has analysed psychophysiology data in this way (Künecke, Hildebrandt, Recio, Sommer, & Wilhelm, 2014; Mackersie & Cones, 2011; Neta, Norris, & Whalen, 2010; Radin, 2004; van Boxtel, 2010); z-scores above 1.96 and below -1.96 were removed. These values were considered as outliers because they fall beyond 2 standard deviations.

Normality was assessed using the Shapiro-Wilk test. No adjustment to the statistical significance using the Bonferroni correction was done for correlational analyses. Perneger (1998) highlights two main problems with the Bonferroni correction: 1) interpretation of findings depend on the number of tests performed, and 2) the likelihood of type II errors is increased. Instead, bias-corrected and accelerated bootstrap confidence intervals were calculated and are reported in square brackets, as suggested by (Field, 2012, 2013).

In studies 2 and 3 participants were exposed to all experimental conditions. For this reason, repeated measures ANOVAs were used. Again, normality was assessed using the Shapiro-Wilk test of normality. Degrees of freedom were corrected using the Greenhouse-Geisser estimate for those cases in which the condition of sphericity was violated (Field, 2013). Simple contrasts[8] were used to better understand between-subject interactions.

[8] Contrasts are used to make comparisons between variables.

Chapter 5:

Exploring electrodermal activity and facial electromyography to objectively measure arousal and valence associated with text

Chapter 5: Exploring electrodermal activity and facial electromyography to objectively measure arousal and valence associated with text

5.1 Overview

This study explores electrodermal activity as a method to measure arousal, and facial electromyography as a method to measure valence, in response to text (words). Electrodermal activity and facial electromyography were also used to obtain measures of arousal and valence for some of the most frequently used words in text messages promoting physical activity, and participant's name, a common personalisation strategy used in text messages.

5.2 Introduction

Health communication for behaviour change seems to be more effective when it reaches people on an emotional as well as rational level and is personalised (Neuhauser & Kreps, 2003). A large body of literature has explored the role of emotions in health communication or public service advertisements (PSAs), and their effect on behaviours such as drinking (Becheur et al., 2008), smoking (Biener et al., 2000; Wong & Cappella, 2009) and consumption of sugar-sweetened beverages (Bleakley et al., 2015).

Targeting fear, guilt, shame and other negative emotions have been widely researched for health promotion, especially for smoking cessation, and anti-alcohol posters and public service advertisements (Becheur & Valette-Florence 2014; Dunlop et al. 2008; Duhachek et al. 2012). In contrast, very little research has been conducted on text only messages (Carrera et al., 2008).

Health communication and behaviour change interventions delivered through text messages have been the focus of research for some years. Several characteristics position them as an effective health communication medium (Preston et al., 2011). However, objective measures of the emotional impact of text messages have not been studied. The use of psychophysiology methods has been suggested to objectively measure and understand emotions in health communication (Nabi, 2014).

Research on emotion has identified arousal, valence and dominance as the three basic dimensions of an emotion (Bradley & Lang, 1994; Russell & Mehrabian, 1977). However, the affective core of an emotional experience can be described by only two of these dimensions: arousal and valence (Reisenzein, 1994). Electrodermal activity (EDA) and facial electromyography (fEMG) are two of the most widely used methods to measure arousal and valence, respectively.

As described in Chapter 1, electrodermal activity, specifically the skin conductance response (SCR), is used to determine levels of arousal (Greenwald, Cook, & Lang, 1989; Lang et al., 1993; Norris et al., 2007). Sweat glands are innervated by the sympathetic nervous system, increasing skin conductivity. Electrodermal activity has been reported to vary directly with reported arousal (Boucsein, 2012; Dawson et al., 2007; Winton, Putnam, & Krauss, 1984).

Changes in skin conductance, however, cannot differentiate whether an experience is pleasant or unpleasant. Facial electromyography, on the other hand, can differentiate these experiences by identifying which facial muscles are activated. Activity over corrugator supercilii (CS) and zygomaticus major (ZM) have been studied for this purpose (Lang et al., 1993; Larsen et al., 2003; Wolf et al., 2005). A limited number of studies have evaluated electrodermal activity and facial electromyography together as means to differentiate positive and negative affect (valence), and high and low arousal on text (Larsen et al., 2003).

The Center for the Study of Emotion and Attention of the University of Florida developed the Affective Norms for English Words (ANEW) (Bradley & Lang, 1999).This is a set of English words that had been rated for valence and arousal to assist researchers investigating emotions. It constitutes the gold standard for these two dimensions. They could, therefore, be used to validate facial electromyography and electrodermal activity as means for objectively measuring valence and arousal; furthermore, determine levels of valence and arousal with new words compared to known values. For example, it would be of interest to learn what are the levels of arousal and valence associated with a person's name – which is frequently used for personalising messages – as it has been found that tailored or personalised text messages are more engaging and effective at changing people's behaviour than untailored or impersonal messages (Bull et al., 2001; Fjeldsoe et al., 2009; Ryan & Lauver, 2002; Trevena, Davey, Barratt, Butow, & Caldwell, 2006).

5.3 Aim and objectives

The aim of this study was to explore facial electromyography as a method to objectively measure valence, as done by Larsen et al. (2003), and electrodermal activity as a method to objectively measure arousal. The objectives of this study were to determine:

- Whether electrodermal activity is associated with arousal.
- Whether facial electromyography is associated with valence.
- Whether the most common words used in text messages promoting physical activity elicit arousal and valence, and its levels, using electrodermal activity and facial electromyography.
- Whether individual differences – exercise engagement and frequency, self-perception or dieting status – can account for differences in electrodermal activity and facial electromyography reactivities for the most common words used in text messages promoting physical activity.
- Whether a person's name, a personalisation strategy commonly used in text messages, elicits arousal and valence, and its levels.

5.4 Methods

The general methodology was described in Chapter 4. The following section describes details specific to this study.

5.4.1 Sample

Forty healthy participants (16 males and 24 females, age-range 18-45 years, *M* = 27.7 years, SD = 6.7 years) meeting the inclusion criteria took part in the study. They received £7 upon completion of the experiment as an incentive.

Facial electromyography data of one participant over corrugator supercilii was removed due to a lack of activity over muscle.

Total removed	Code (s)	Signal	Removal justification
1	005	CS	No CS activity, participant's muscle unresponsive in this site.

Table 5.1 Signal exclusion details.

5.4.2 Ethics

Ethical approval for this study was given by the Institute of Psychological Sciences Research Ethics Committee on 15th October 2013 (see Appendix I). This study's reference number was 13-0140. The data collection took place from 22nd October 2013 to 19th December 2013.

5.4.3 Experimental procedure

Before the session

After potential participants read the participant information sheet and agreed to take part in the study, a date and time for them to visit the lab was set. Participants were asked to refrain from consuming caffeine three hours prior to the session. The researcher met participants in the foyer of the Institute of Psychological Sciences.

The session

Participants were escorted and introduced to the psychophysiology laboratory by the researcher. After signing the consent form, participants were asked to wash their hands with water and clean their face with a disposable cleansing towel. Electrodes were attached in the index and middle fingers of the participant's non-dominant hand, and left side corrugator supercilii muscle and zygomaticus major muscle (see chapter 4 section 4.5.1 for a detailed description of the session). The experimental task took approximately 45 minutes, and the session's total time was typically 90 minutes.

The experiment

This experiment consisted of a computer task in which participants were presented with a set of 30 words (see section 5.4.3). They were asked to read each word in silence and whenever they read a nonsense word they would hit any keyboard key to demonstrate that they read it. This task was designed to make sure participants paid attention and read every single word during the experiment.

Each 30-words set was presented in random order every time, and participants saw the set a total of five times. Once the set had been completed, a 60-seconds resting time allowed participants to rest before it was presented again.

The following instructions were given to participants through the computer screen:

Welcome screen

`Welcome to the Psychophysiology Laboratory!`

Instructions screen 1

`Welcome! The experiment is about to begin.`

`Please avoid moving as much as possible while the experiment is running.`

`<<Press SPACE to continue>>`

Baseline recording screen

`Please relax. This is a 5-minute period to allow you to adjust to the laboratory environment before proceeding with the experiment.`

Instructions screen 2

`You will see a series of words on the computer screen. Please read each word in your mind. If you read a nonsense word, please press any key to indicate you've seen it.`

`Prior to each word you will see a fixation cross (+) that will help you focus your eyes on the centre of the screen.`

Try to be as relaxed as possible and avoid moving your hand while we measure your physiological responses to each word.

<<Press SPACE to go to a practice run>>

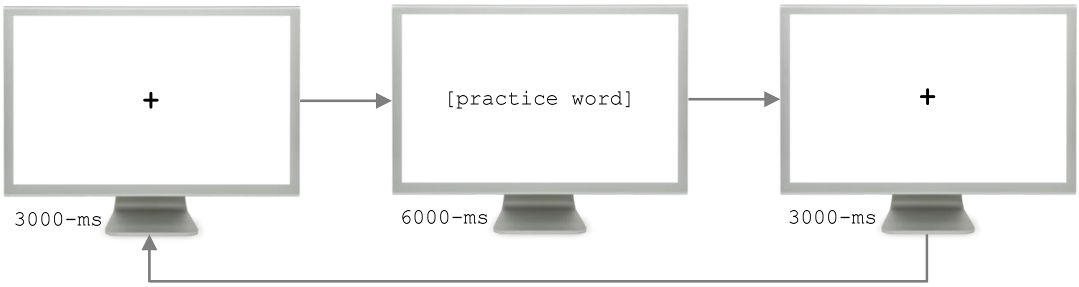

Figure 5.1 Depiction of practice block screens.

End of practice screen

End of Practice

Resting period screen

60 seconds resting period.

Experiment to continue screen

The experiment is about to continue.

Please remember to read each word in your mind. If you read a nonsense word, please press any key to indicate you've seen it.

Remember to avoid moving your hand as much as possible while the experiment is running.

When you are ready to continue press <<SPACE>>

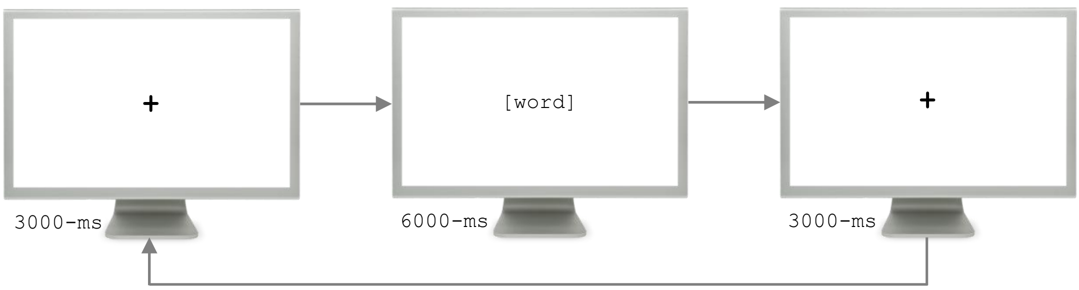

Figure 5.2 Depiction of experiment screens.

End of block screen

`End of Block`

After this screen, participants were redirected to the resting period screen until the 5 blocks were completed.

End of experiment screen

`End of experiment`

If there were any events during the experiment that could translate into artifacts (e.g. coughing, sneezing, movement), the researcher made a note of the type of event and the time, as it appeared in the Biopac session. During the data extraction process, these notes were used to exclude data corresponding to those stimuli.

After the experiment

Electrodes were tested again at the end of the experiment to ensure they were still recording properly. After that, they were removed, participants completed a questionnaire on self-perception and eating behaviours, were debriefed, given the £7, thanked, and were escorted to the exit.

After the session

Electrodermal activity and facial electromyography recordings were cleaned and filtered before extracting data (see chapter 4 section 4.5.4).

5.4.4 Stimuli

The stimuli used for this study was taken from the Affective Norms for English Words (ANEW), which was developed and validated by the Centre for the Study of Emotion and Attention of the University of Florida. This set of words has been rated in terms of self-reported valence and arousal using a 9-point Likert scale to create a standard set of stimuli for use in studies involving emotion and attention (Bradley & Lang, 1999).

Twenty-four words were taken from this set for this study (see table 5.2). Six of these words were randomly selected to be used during the practice. The 24 words were selected to include high, neutral and low arousal, and high, neutral and low valence.

The five most frequently words used in text messages for physical activity and weight loss interventions were included, of which exercise was already part of the ANEW set. These words were selected through a frequency analysis performed over the libraries used by Nguyen et al. (2012), Shaw et al. (2013), Joo & Kim (2007), Shapiro et al. (2012), Shapiro et al. (2008) and Sirriyeh et al. (2010). Participant's name or nickname was also included as part of the stimuli.

Six nonsense words were included to give participants a task to perform during the experiment. This intended to ensure that participants were reading the words appearing on-screen. The nonsense words used in this study were taken from a website that generates these type of words[9]. They are generated using an algorithm that takes into account the frequency list of phonemes that occur in real English words. They may look like legitimate English words and even sound as legitimate English words.

No.	Word	ANEW Word Number	Valence	Arousal	
1	rollercoaster	528	8.02	8.06	(used for practice)
2	explosion	1524	5.18	7.93	
3	killer	244	1.89	7.86	
4	nightmare	295	1.91	7.59	
5	war	482	2.08	7.49	(used for practice)
6	sexy	530	8.02	7.36	
7	hysterical	1708	5.29	7.36	
8	kiss	248	8.26	7.32	
9	exercise	155	7.13	6.84	(from published SMS)
10	clown	1311	5.39	5.43	
11	music	291	8.13	5.32	
12	news	901	5.3	5.17	
13	free	172	8.26	5.15	(used for practice)
14	echo	1470	6.17	5.07	(used for practice)
15	infection	228	1.66	5.03	
16	funeral	178	1.39	4.94	

Table 5.2 List of words used as stimuli (in order of arousal).

[9] http://www.soybomb.com/tricks/words/

No.	Word	ANEW Word Number	Valence	Arousal	
17	family	158	7.65	4.8	
18	death	100	1.61	4.59	(used for practice)
19	pale	1935	3.17	3.50	
20	chair	66	5.08	3.15	(used for practice)
21	pillow	315	7.92	2.97	
22	nun	909	4.93	2.93	
23	table	426	5.22	2.92	
24	bored	48	2.95	2.83	
25	relax	2069	7.87	2.47	
26	[Name]	X	unknown	unknown	(added for testing)
27	you	X	unknown	unknown	(from published SMS)
28	activity	X	unknown	unknown	(from published SMS)
29	today	X	unknown	unknown	(from published SMS)
30	physical	X	unknown	unknown	(from published SMS)
31	wolide	-	-	-	(nonsense word)
32	hysineral	-	-	-	(nonsense word)
33	fim	-	-	-	(nonsense word)
34	moof	-	-	-	(nonsense word)
35	napsate	-	-	-	(nonsense word)
36	retrating	-	-	-	(nonsense word)
37	thrist	-	-	-	(nonsense word)

Table 5.2 (contd.) List of words used as stimuli (in order of arousal).

5.5 Statistical analysis

Mean electrodermal activity reactivities and mean facial electromyography reactivities for each word were calculated after being filtered and transformed (see chapter 4, section 4.5.4). Reactivities were standardised within participant using z-scores. After testing for normality using the Shapiro-Wilk tests, it was found that data were normally distributed, so the Pearson correlation coefficient was used (see Chapter 4, section 4.5.10).

5.5.1 Association between arousal and electrodermal activity

The association between arousal and electrodermal reactivity was established by calculating the Pearson correlation coefficient. Standardised mean electrodermal activity reactivity values for each word were calculated for each block across participants. These means were correlated to the arousal values taken from the ANEW set.

Practice words, nonsense words and the most frequent words used in text messages for weight reduction and physical activity interventions, except for *exercise* were excluded from this analysis because there was no associated arousal value for them in the ANEW set.

5.5.2 Association between valence and facial electromyography

As with arousal and electrodermal activity reactivity, the association between valence and facial electromyography was explored by calculating the Pearson correlation coefficient. Mean standardised corrugator supercilii reactivity and zygomaticus major reactivity values across all 5 blocks were calculated and the same words were excluded for the same reason.

5.5.3 Individual differences

A mixed design ANOVA was used to determine if factors such as exercise, frequency, self-perception and dieting status had an effect on how people reacted to the most frequently used words in text messages, especially to exercise. Where Maulchy's test indicated a violation of the assumption of sphericity the degrees of freedom were corrected using Greenhouse-Geisser estimates.

5.6 Results

5.6.1 Participants characteristics

Table 5.3 summarises the characteristics of the participants that took part in this study.

Participants characteristics	*n* = 40
Age (years), mean (SD)	27.7 (6.7)
Sex	
Males	16 (40%)
Females	24 (60%)
BMI (kg/m^2), mean (SD)	22.5 (4.5)

Table 5.3 Participants characteristics.

Participants characteristics	*n* = 40
Dieting status	
Dieting to lose weight	2 (5%)
Dieting or watching as to not put on weight	12 (30%)
Not dieting	26 (65%)
Already engaged in regular exercise	
Yes	28 (70%)
No	12 (30%)
Exercise frequency	
< 3 days a week	25 (62.5%)
3 days a week	3 (7.5%)
> 3 days a week	9 (22.5%)
everyday	2 (5%)
failed to report	1 (2.5%)
Adjusted: people engaged in regular exercise	
Yes	15 (37.5%)
No	25 (62.5%)
Self-perception	
Overweight	16 (40%)
About the right weight	19 (47.5%)
Underweight:	5 (12.5%)

Table 5.3 Participants characteristics (contd.).

5.6.2 Associations

5.6.2.1 Valence and corrugator supercilii reactivity

There were significant strong negative associations between valence and corrugator supercilii reactivity during block 2, $r = -.49$ [-0.78, -0.01], $p = 0.032$ (see Figure 5.3), and during block 3, $r = -.62$ [-0.82, -0.36], $p = 0.005$ (see Figure 5.4). Overall corrugator supercilii reactivity was significantly related to pleasure, $r = -.53$ [-0.77, -0.09], $p = 0.02$ (see Figure 5.5).

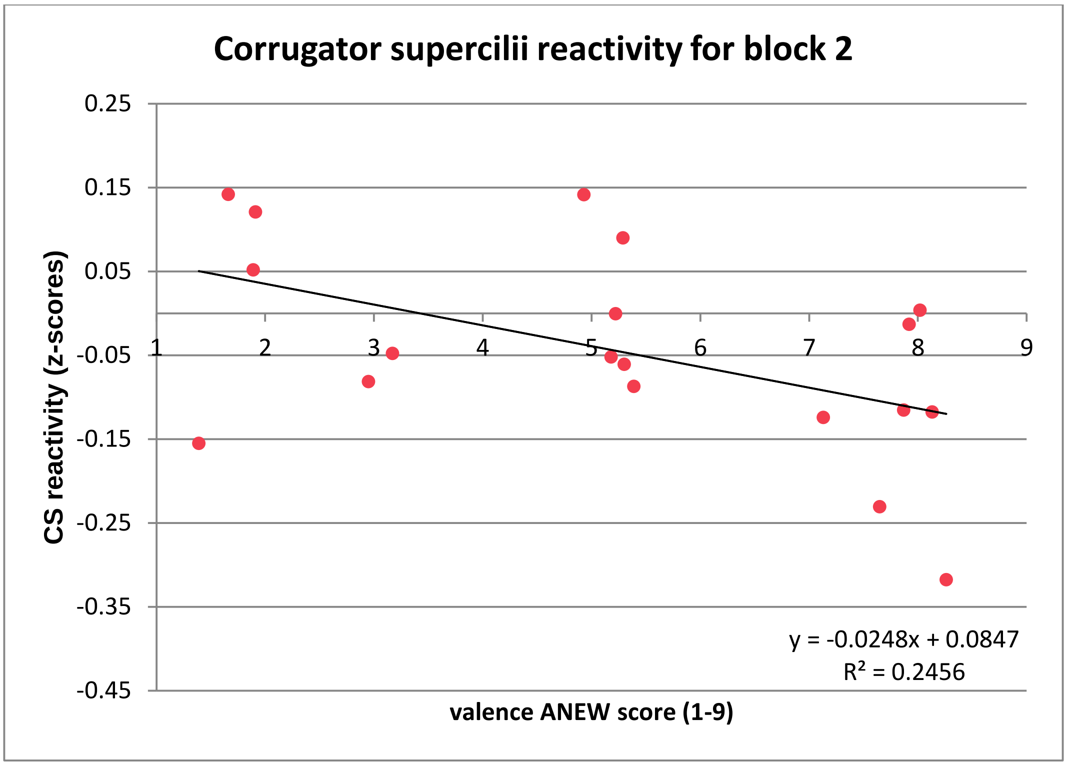

Figure 5.3 Association between corrugator supercilii reactivity and valence ratings taken from the ANEW set during block 2 showing a strong negative association.

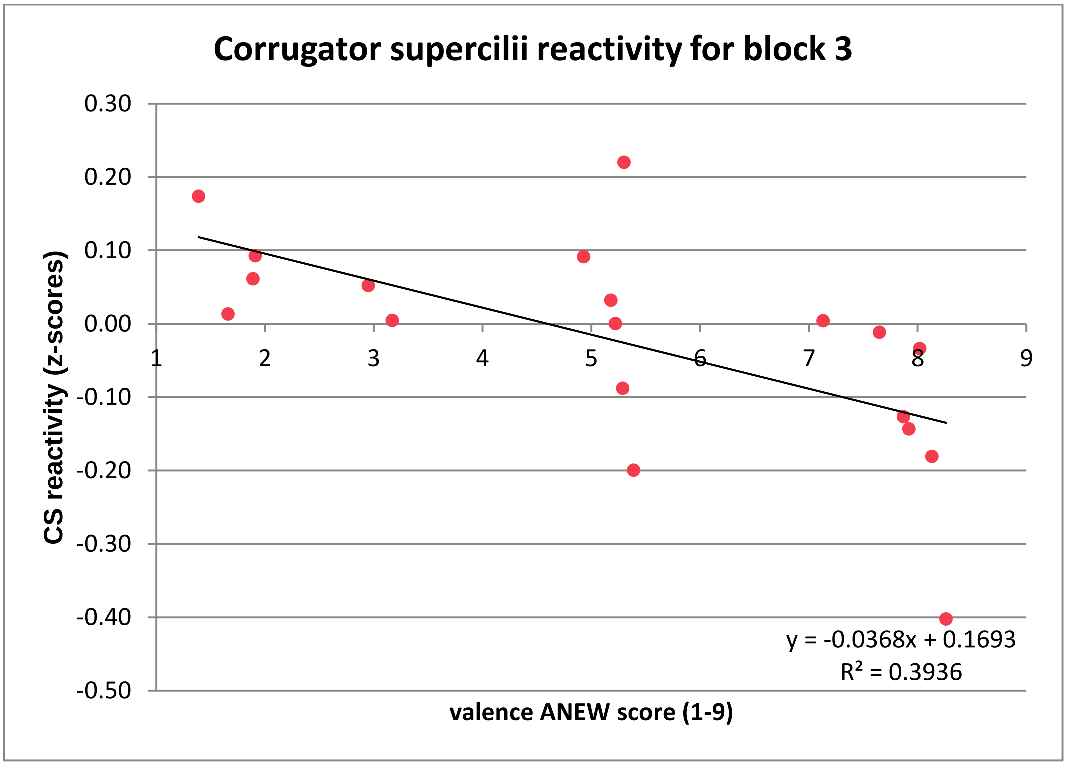

Figure 5.4 Association between corrugator supercilii reactivity and valence ratings taken from the ANEW set during block 3 showing a strong negative association.

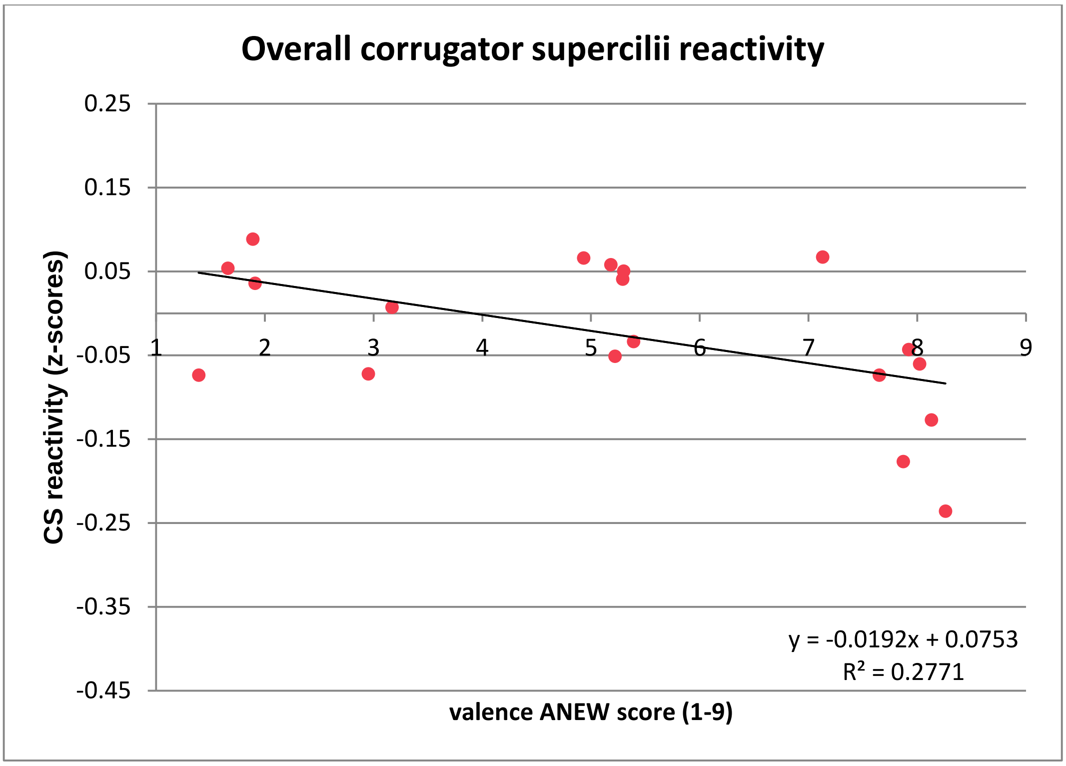

Figure 5.5 Association between overall corrugator supercilii reactivity (blocks 1-5) and valence ratings taken from the ANEW set showing a strong negative association.

5.6.2.2 Valence and zygomaticus major reactivity

Zygomaticus major reactivity during block 1 was negatively associated with valence, r = -.62 [-0.83, -0.27], p = 0.005 (see Figure 5.6).

No other significant associations were found.

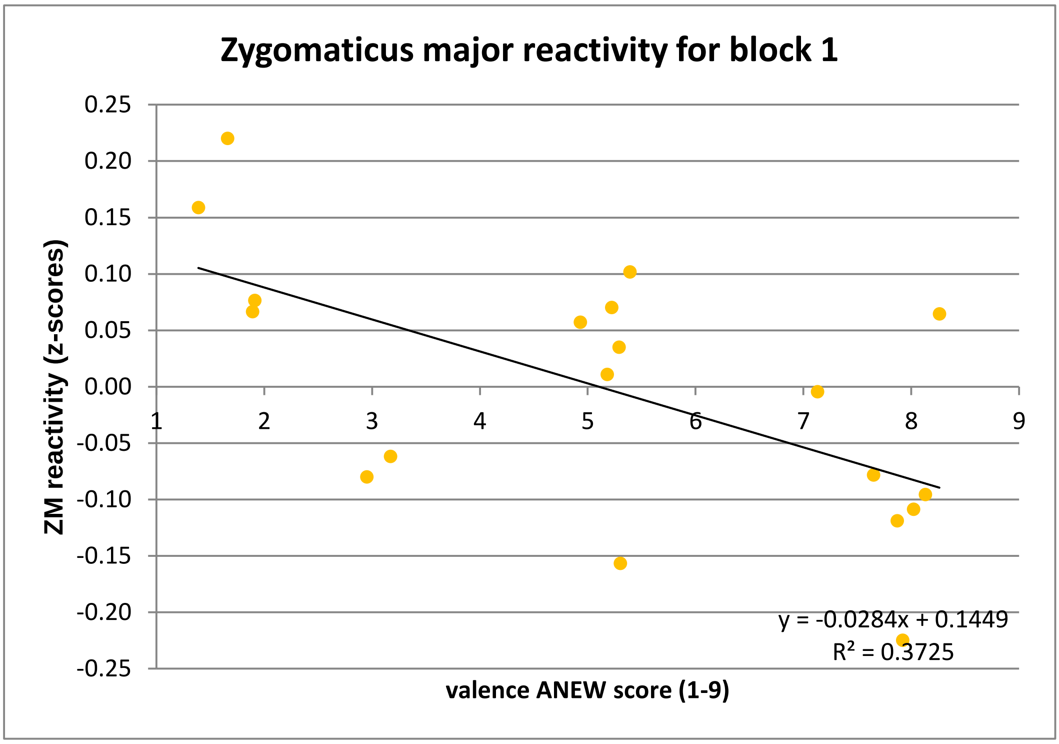

Figure 5.6 Association between zygomaticus major reactivity and valence ratings taken from the ANEW set showing a strong negative association during block 1.

5.6.2.3 Arousal and electrodermal activity, early EDA, late EDA

There were positive strong associations for block 1 between electrodermal activity and arousal, r = .55 [0.27, 0.76], p = 0.015 (see Figure 5.7), early EDA and arousal, r = .46 [0.1, 0.71], p = 0.05 (see Figure 5.8), and late EDA and arousal, r = .61 [0.38, 0.83], p = 0.006 (see Figure 5.9).

No other significant associations were found.

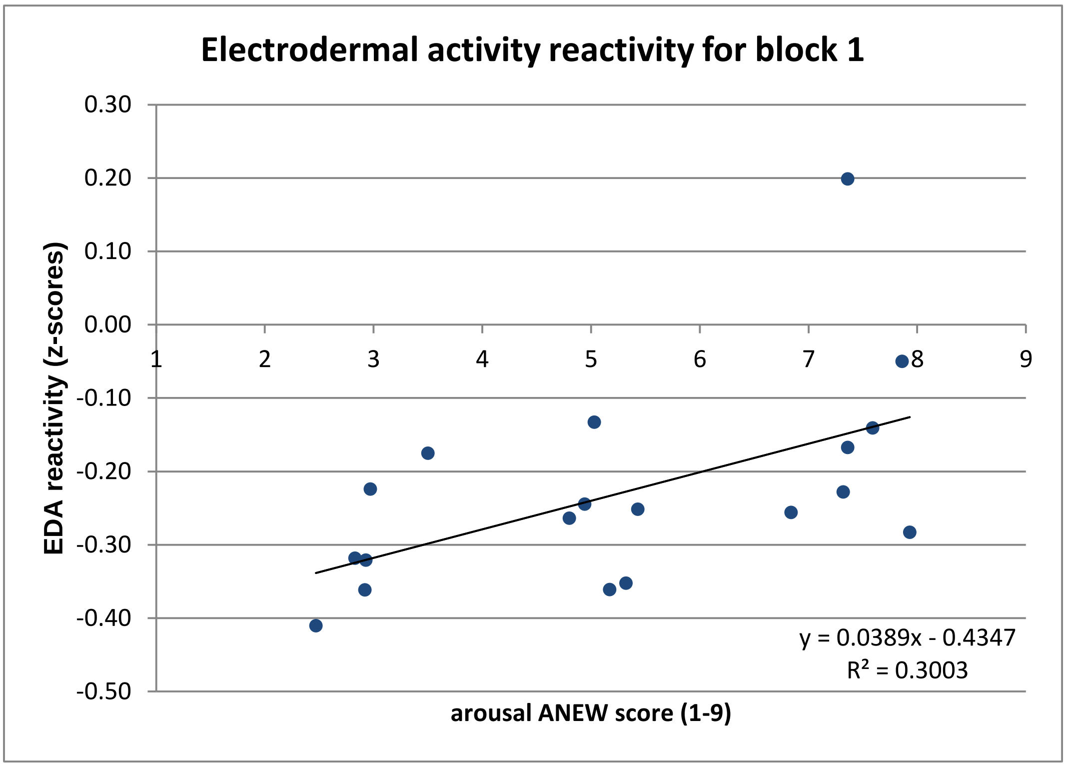

Figure 5.7 Association between electrodermal activity reactivity and arousal ratings taken from the ANEW set showing a strong positive association during block 1.

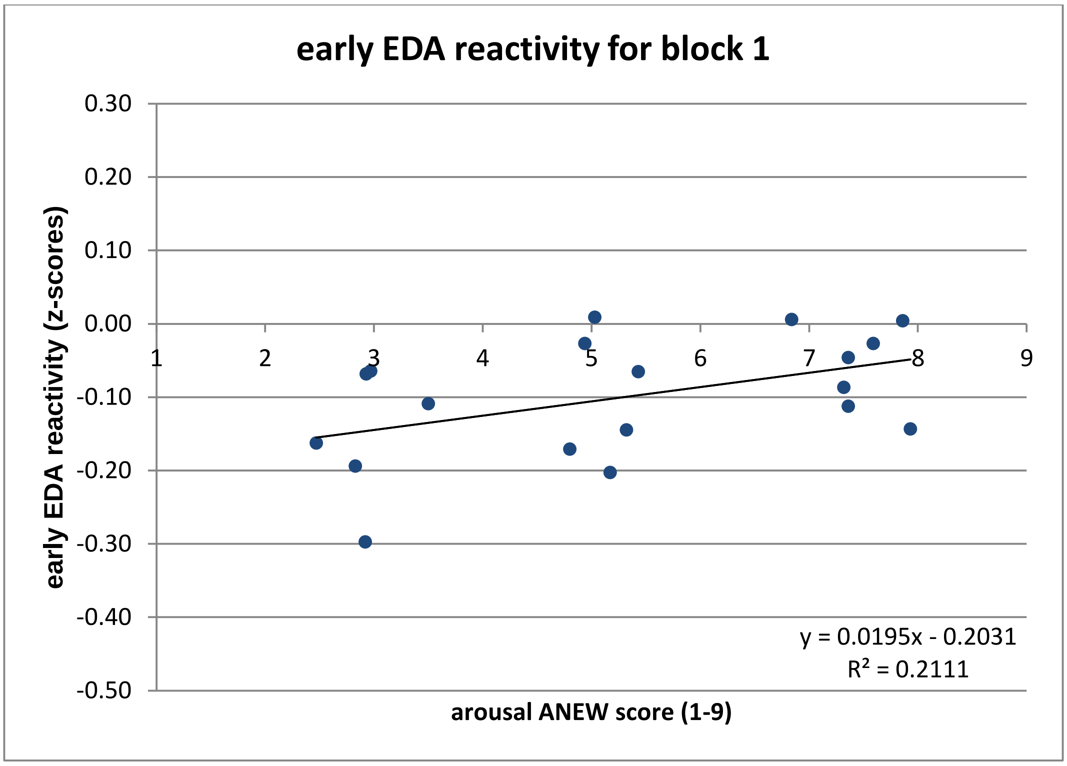

Figure 5.8 Association between early EDA reactivity during block 1 and arousal ratings taken from the ANEW set showing a strong positive association.

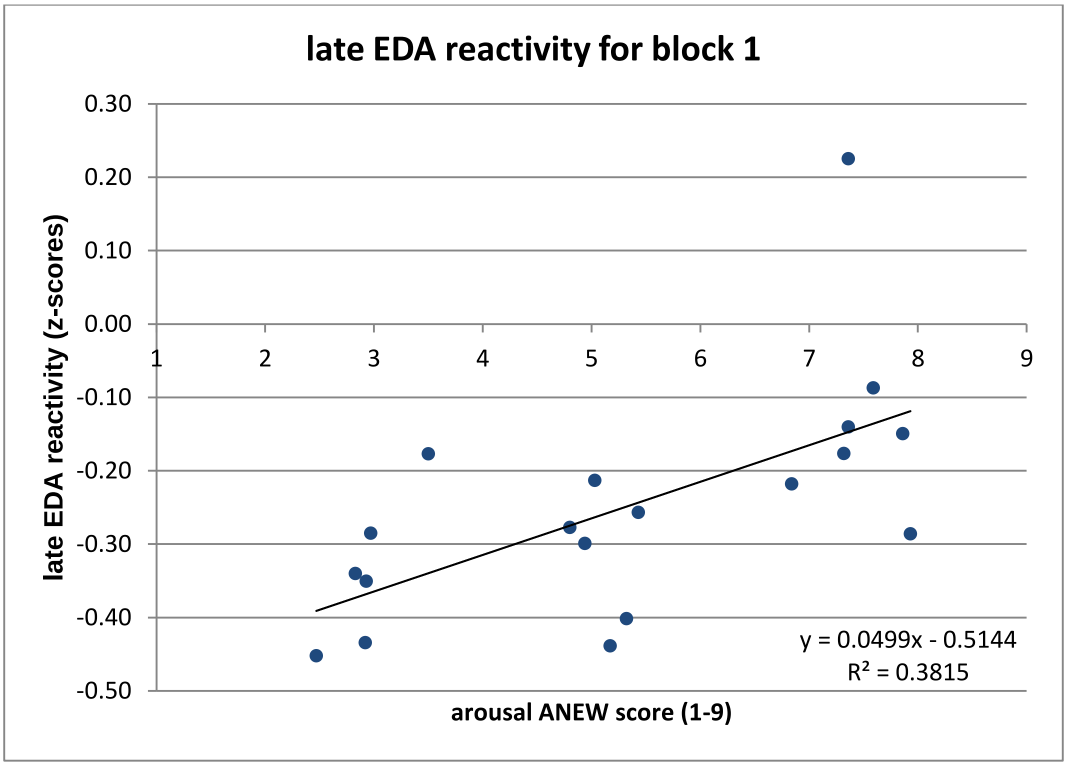

Figure 5.9 Association between late EDA reactivity during block 1 and arousal ratings taken from the ANEW set showing a strong positive association.

5.6.2.4 Valence and electrodermal activity, early EDA and late EDA

There were no significant associations between valence and electrodermal activity, early EDA and late EDA.

5.6.2.5 Arousal and corrugator supercilii

There were no significant associations between arousal and corrugator supercilii reactivity.

5.6.2.6 Corrugator supercilii and electrodermal activity, early EDA and late EDA

There were no significant associations between corrugator supercilii and electrodermal, early EDA and late EDA reactivities.

5.6.3 Electrodermal activity and facial electromyography reactivities to the most common words used in text messages promoting physical activity

The Tables below show the standardised scores for the most common words used in messages promoting physical activity. Table 5.4 shows the mean standardised scores for reactivity values of electrodermal activity, early EDA and late EDA during the first block. Table 5.5 shows the standardised scores for corrugator supercilii reactivity for blocks 2 and 3, and the overall mean standardised score for corrugator supercilii reactivity.

	Mean z-score		
	EDA	*early EDA*	*late EDA)*
you	-0.21	-0.11	-0.27
activity	-0.37	-0.19	-0.42
today	-0.22	-0.05	-0.33
exercise	-0.26	0.01	-0.22
physical	-0.24	-0.03	-0.22
[NAME]	0.55	0.44	0.68

Table 5.4 Standardised scores for electrodermal activity, early EDA and late EDA during block 1.

	Mean z-score		
	Overall CS	*CS (block 2)*	*CS (block 3)*
you	0.00	-0.13	-0.11
activity	-0.03	-0.10	-0.02
today	-0.04	-0.18	0.09
exercise	0.07	-0.12	0.00
physical	0.00	0.10	0.07
[NAME]	-0.34	-0.33	-0.24

Table 5.5 Standardised scores for corrugator supercilii.

5.6.4 Individual differences

No significant interaction effects were found between gender, exercise engagement, frequency, self-perception or dieting-status, and corrugator supercilii, electrodermal activity, early EDA and late EDA reactivities.

5.6.5 Participant's name arousal and valence as measured through electrodermal activity and facial electromyography

Participant's name was the most arousing word during block 1, the first time that participants saw their name on the screen. This effect can be seen for electrodermal activity reactivity – mean electrodermal activity reactivity for the whole 6000-ms that the stimulus is on-screen (see Figure 5.10), early EDA – the first 3000-ms that the stimulus in on-screen (see Figure 5.11) and late EDA – the last 3000-ms that the stimulus is on-screen (see Figure 5.12). It was also the word that elicited less corrugator supercilii reactivity overall (see Figure 5.13), the lowest that elicited any corrugator supercilii reactivity in block 2 (see Figure 5.14) and the second lowest in block 3 (see Figure 5.15).

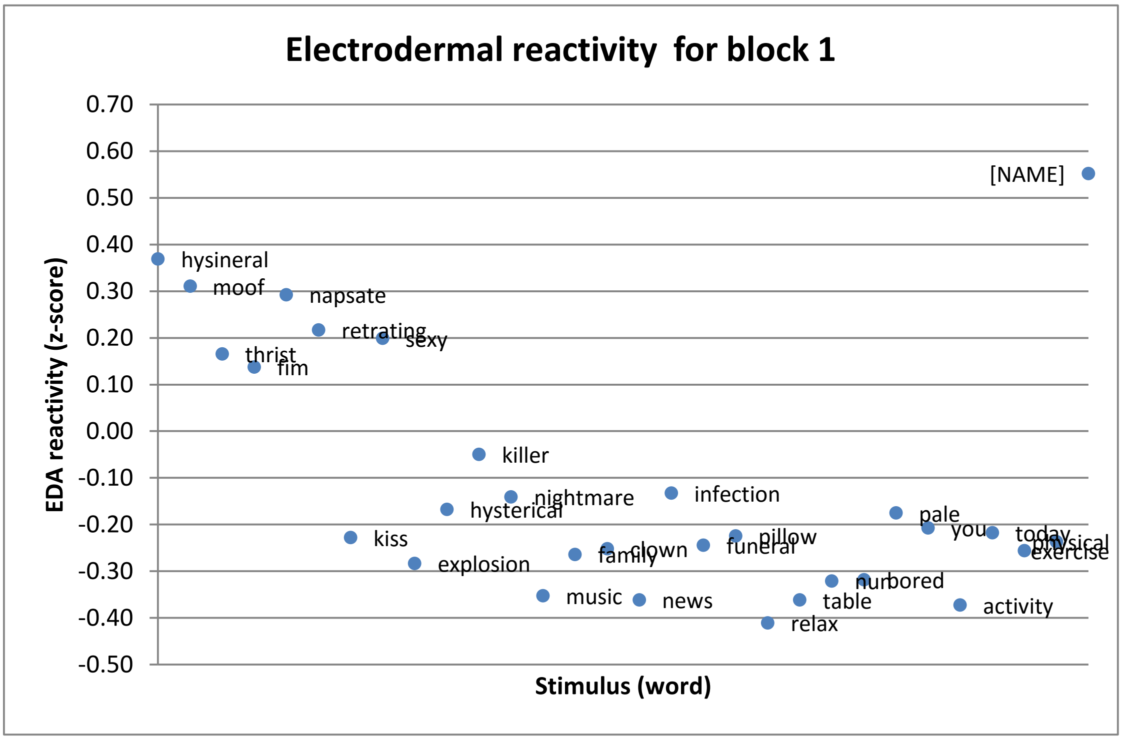

Figure 5.10 Electrodermal activity reactivity elicited by all the words used in the experiment during block 1. Participant's name elicited the strongest response.

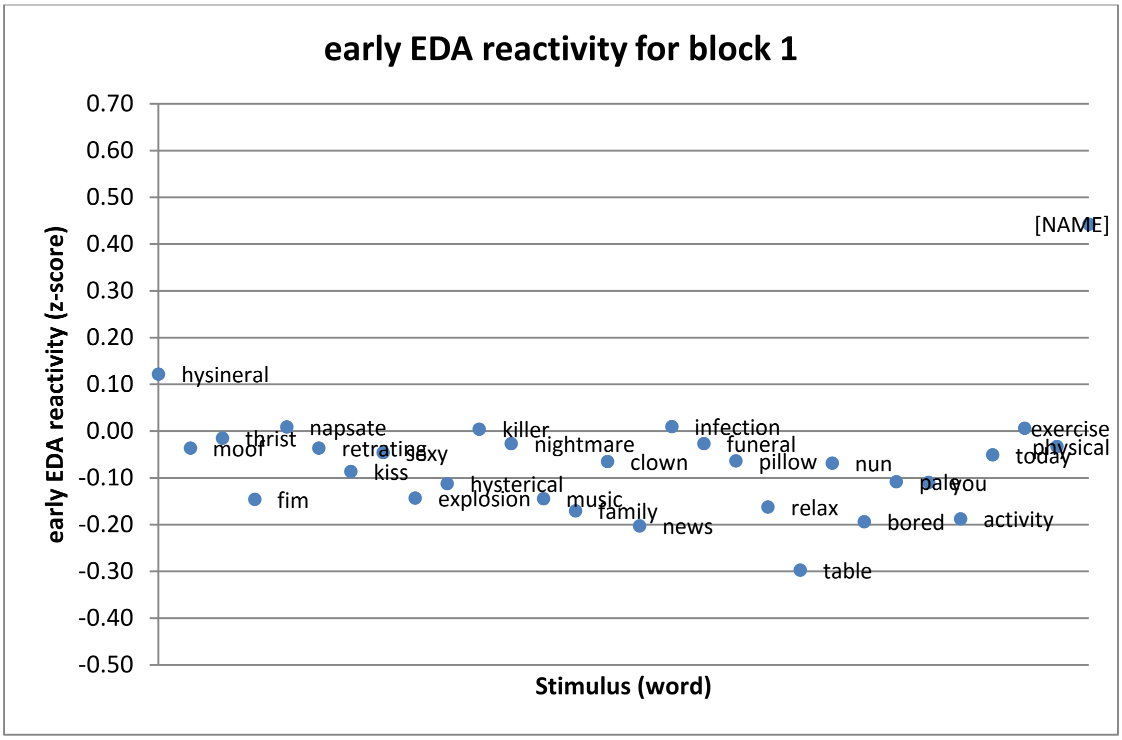

Figure 5.11 Early EDA activity reactivity elicited by all the words used in the experiment during block 1. The strongest response was elicited by the participant's name.

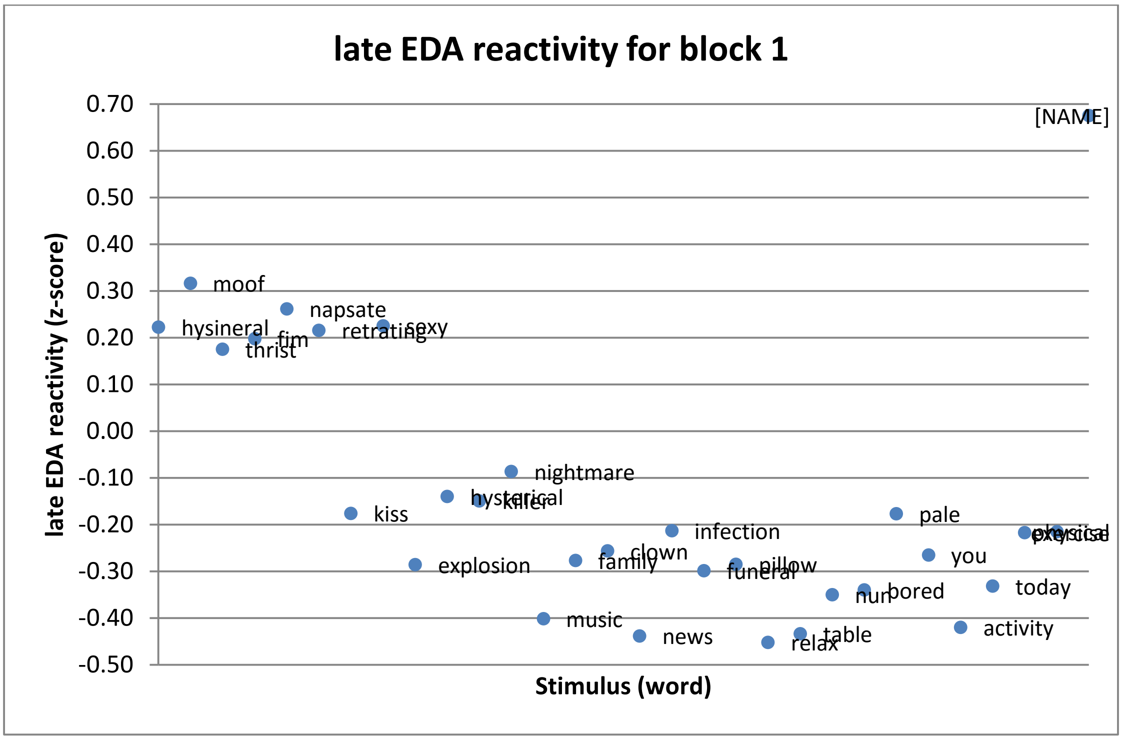

Figure 5.12 Late EDA reactivity elicited by all the words used in the experiment during block 1. It was participant's name what elicited the strongest response.

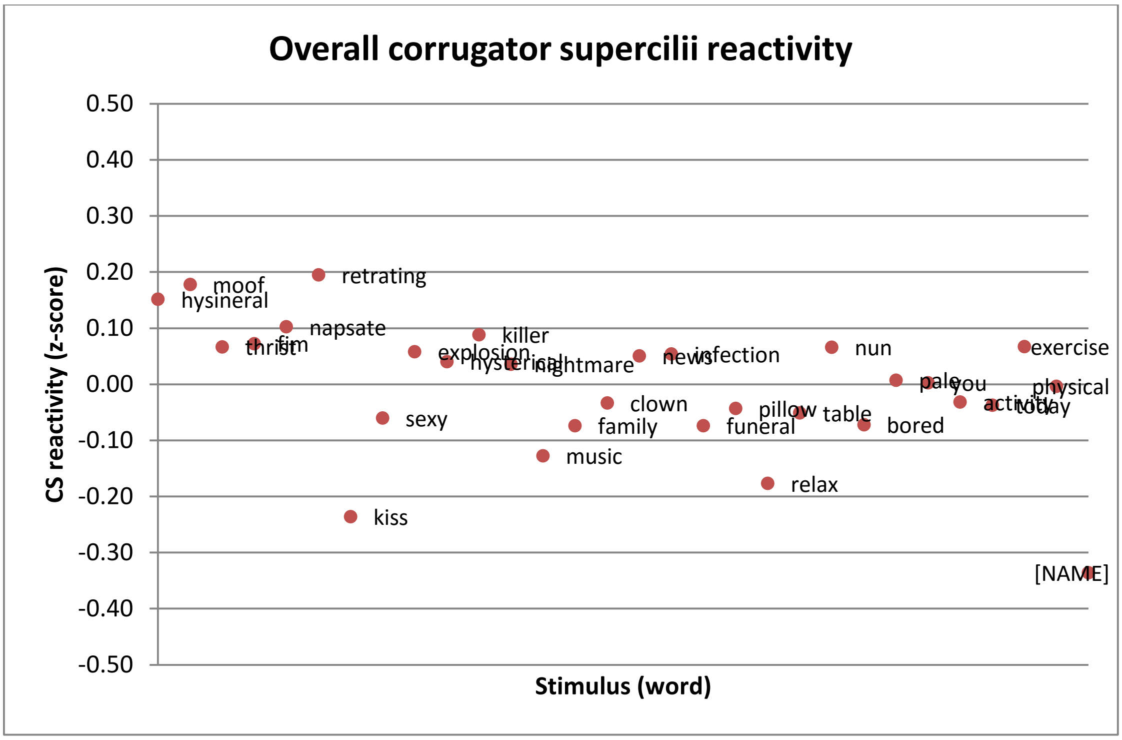

Figure 5.13 Overall corrugator supercilii reactivity elicited by all the words used in the experiment during blocks 1-5. Participant's name elicited the smallest response from corrugator supercilii.

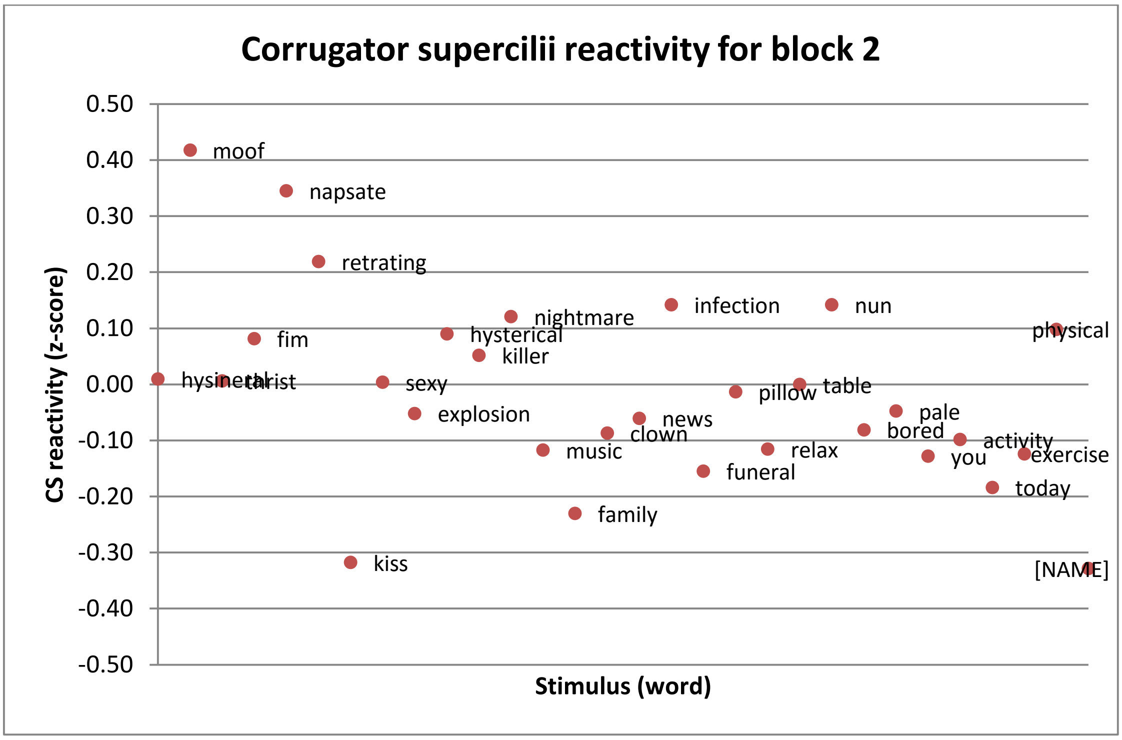

Figure 5.14 Corrugator supercilii reactivity elicited by all the words used in the experiment during block 2. Participant's name elicited also the smallest response in this block.

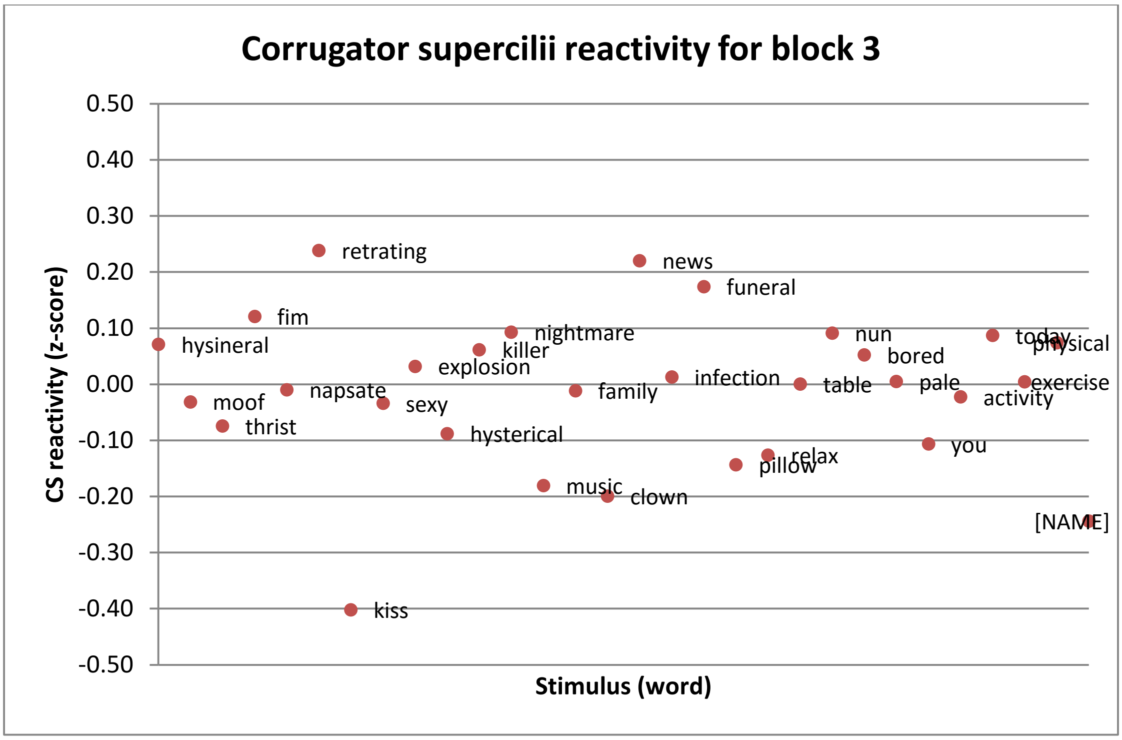

Figure 5.15 Corrugator supercilii reactivity elicited by all the words used in the experiment during block 3. Participant's name elicited a small response, however kiss elicited the smallest response.

5.6.6 Nonsense words recognition

Participants successfully recognised more than 90% of the nonsense words throughout the 5 blocks. Table 5.6 below summarises the results for the nonsense words recognition task.

Block 1			Block 2			Block 3			Block 4			Block 5		
C	M	I	C	M	I	C	M	I	C	M	I	C	M	I
90.4 %	0.4 %	2.1 %	93.3 %	0.4 %	2.08 %	94.2 %	0 %	2.92 %	94.6 %	0 %	2.5 %	96.3 %	0 %	1.7 %

Table 5.6 Percentage of nonsense words recognised correctly (C), missed (M) and incorrectly recognised (I) during each block.

5.7 Discussion

The aim of the present study was to explore electrodermal activity to objectively measure arousal and facial electromyography to objectively measure valence. Results show that electrodermal activity was strongly associated with arousal and activity over corrugator supercilii was strongly associated with valence. Participant's name elicited the strongest electrodermal activity response.

5.7.1 Electrodermal activity and arousal

The strong positive association of arousal scores from the ANEW set and electrodermal activity reactivity (mean, early and late) during block 1 was consistent with findings from the literature (Boucsein, 2012; Bradley, 2000; Lang et al., 1993). No associations were found for blocks 2 – 5. This can be explained by the habituation effect, which may occur after two or three trials (Dawson et al., 2007) for electrodermal activity.

No associations were found between arousal and corrugator supercilii reactivity, which was expected.

5.7.2 Facial electromyography and valence

The negative association between valence scores from the ANEW set and corrugator supercilii reactivity was consistent with similar findings by Larsen et al. (2003). However, the negative association between zygomaticus major reactivity and valence scores was not consistent with the literature (Larsen et al. 2003; Lang et al. 1993). The direction of the association between zygomaticus major reactivity and valence was negative for this experiment, however, a positive association was expected as zygomaticus major reactivity has been found to be associated with positive valence (Lang et al., 1993; Larsen et al., 2003). After a close examination of the electrode, this was found to be faulty, which could have caused the observed inverse association.

The psychophysiology literature has shown a strong linear effect of valence on corrugator supercilii and zygomaticus major activity (Cacioppo et al., 1992; Cacioppo, Petty, Losch, & Kim, 1986; Greenwald et al., 1989; Lang et al., 1993). Corrugator supercilii activity is strongest for low valence stimuli – in particular, negative words like explosion or killer.

Averaging across all five blocks, corrugator supercilii reactivity was found to be negatively associated to valence. The strongest association was found for block 3, but no statistically significant association was found for block 1, which was when participants saw the words for the first time, or blocks 4 and 5. The absence of reactivity for the last 2 blocks could be the result of habituation. The absence of an association during the first block could be the result of the very small number of stimuli used, compared to other studies. Findings by Larsen et al. (2003) suggest that valence has a weaker effect over corrugator supercilii activity when words are used as stimuli, compared to sounds or images.

Finding no association between valence and electrodermal activity (mean, early and late) supports the independency of electrodermal activity, which measures a different dimension, arousal.

5.7.3 Electrodermal activity and corrugator supercilii reactivities to the most common words

Reactivities to the most common words used in text messages promoting physical activity showed that participant's name was the most arousing. All other words were no more arousing nor more positive or negatively perceived as neutral words. This response, in terms of electrodermal activity, was expected.

It has been suggested that personalised communication is more effective (Jensen et al., 2012; Noar et al., 2007). Head et al (2013) found in a meta-analysis of text messaging interventions that personalisation strategies, such as using a person's name, increased the intervention efficacy. Participant's high electrodermal reactivity to their name suggests that this personalisation strategy could increase a text message's emotional impact, rather than using the personal pronoun *you*.

5.7.4 Individual differences

No individual differences were found for corrugator supercilii reactivity nor electrodermal activity reactivity. A difference in arousal was not observed for the word *exercise* between people engaging regularly in physical activity and people not regularly engaged in physical activity. This could be explained by the fact that exercise was seen as just another stimulus and not a word directed specifically to participants. Because this was an exploratory study and no evidence has been found to support this claim, it is suggested that this could be further investigated in future research.

5.7.5 Nonsense words recognition

Over 90% of the nonsense words were correctly identified throughout the experiment, increasing participant's accuracy every block. The word *nun* was sometimes misidentified as a nonsense word, while the word *thrist* was sometimes missed.

During the debrief some participants reported to have been unsure if the word *thrist* was a typographical error or was, in fact, a nonsense word; however, participants were informed from the beginning that there were no typographical errors and if they read a word that made no sense, even if it resembled an English word, they should identify it by pressing any key on the keyboard.

The word *nun*, for some participants, was a word they had never heard or read before. This was true for both native and non-native English speakers. These words may have introduced some noise to the experiment. Nonetheless, a very high percentage of the words was successfully recognised during the first block and this increased after watching the set of words several times, which is an indication that participants were reading each word and were paying attention to what was presented on-screen.

5.7.6 Limitations

There are a number of issues and limitations worth noting for this study. Firstly, the problems found with the electrode to measure activity over zygomaticus major made it impossible to analyse the recorded data. Therefore, it had to be excluded from the analysis and no statistical analysis was performed to explore the association between zygomaticus major and valence (except for the correlation for block 1).

Secondly, although the results from this study show strong associations between corrugator supercilii and valence, and electrodermal activity and arousal, a small number of words with known values of arousal and valence was used (19). The study conducted by Larsen et al (2003) used 60 words. A much stronger association could perhaps have been obtained increasing the number of stimuli with known values and eliminating the repetitions of the set.

Thirdly, participants did not rate the words for arousal and valence. Using the Self-Assessment MANIKIN developed by Bradley & Lang (1994), these ratings could have been compared to the values for arousal and valence of the words from the ANEW list, and analysed to see their relationship with corrugator supercilii and electrodermal activity reactivities.

Lastly, words such as *weight* and *diet* were not tested. These words could have shown a difference in corrugator supercilii and electrodermal reactivity, rather than *exercise*. Including participant's preferred physical activity as a stimulus could also have been useful to observe differences between this and *exercise* or *activity*.

5.8 Summary

The strong relationship between psychophysiology measures and the known rating values for words taken from the ANEW list shows that facial electromyography and electrodermal activity give useful insights into people's emotional reactions to words. These methods could be used to evaluate SMS messages before deploying them in an intervention and thus improve the emotional impact of the SMS library. Participants' responsiveness to their name supports recommendations to personalise SMS messages for behaviour change to increase emotional impact. Surprisingly, participant's name was not used in any of the 5 text message libraries for physical activity promotion that were accessed.

The next chapter will present the findings of study 2 in which levels of arousal and valence were compared for messages successful at increasing people's physical activity against unsuccessful messages to explore the utility of psychophysiological methods (EDA and fEMG) to inform text message-based interventions.

Chapter 6:

Comparing affective and cognitive (instrumental) messages using psychophysiological measures

Chapter 6: Comparing affective and cognitive (instrumental) messages using psychophysiological measures

6.1 Overview

This chapter presents the findings of study 2. Affective and cognitive (instrumental) messages were compared using electrodermal activity and facial electromyography. Participant’s self-reported arousal and valence were also compared for these two types of messages. Self-reported arousal and valence were measured using the MANIKIN designed and validated by Bradley & Lang (1994).

6.2 Introduction

The theory of reasoned action (Fishbein & Ajzen, 1975) and its extension, theory of planned behaviour (Ajzen, 1985, 1991), have been widely used as theoretical frameworks to design interventions aimed at increasing physical activity (French et al., 2005; Ghahremani, Niknami, & Nazari, 2012; Rhodes & Courneya, 2005; Sirriyeh et al., 2010). It has been suggested that applications of the theory of planned behaviour should consider affective (emotions) and not just cognitive or instrumental (attitude and self-efficacy) determinants of behaviour (French et al., 2005).

Over the last few years some research has focused on the impact of affective attitudes compared to cognitive or instrumental attitudes (Conner, Rhodes, Morris, McEachan, & Lawton, 2011; Kiviniemi, Voss-Humke, & Seifert, 2007; Lawton, Conner, & McEacham, 2009; Lowe, Eves, & Carroll, 2002). Correlational data has strongly supported the importance of affective attitudes to determine intention and action for several health behaviours (Conner, 2013; Lawton et al., 2009).

Research on physical activity has shown that affective attitudes have medium sized effects on behaviour in adults and adolescents (Conner, 2013). Affective messages have been found to be more effective to promote physical activity than cognitive messages (Kiviniemi et al., 2007; Morris et al., 2015; Sirriyeh et al., 2010), and, also, appear to be effective for other health related behaviours. This suggests that interventions could usefully target affective consequences of engaging in healthy behaviours (Lawton et al., 2009).

Changes in affect can be reflected in a number of measureable physiological reactions that can be objectively measured through electrodermal activity and facial electromyography (Codispoti et al., 2001). Results from Chapter 5 showed a strong association between measured and self-reported arousal and valence using these techniques, as have other similar studies (Boucsein et al., 2012; Cacioppo et al., 1992; Lang et al., 1993; Larsen et al., 2003).

Affective messages have been found to lead to more effective health communication than cognitive messages. Therefore, affective messages should be more arousing and perceived as more positive than cognitive messages. Hence, it should be possible to objectively measure the effect that these type of messages have on the receiver using psychophysiology to understand the effect of a message on its receiver, and thus design more effective health promotion messages.

6.3 Aim and objectives

This study aimed to measure arousal and valence using psychophysiology, self-reported arousal and valence, and message recall as 3 possible methods to distinguish affective from cognitive messages. The objectives of this study were to:

- Compare arousal – measured through electrodermal activity – for affective and cognitive messages.
- Compare valence – measured through facial electromyography – for affective and cognitive messages.
- Compare participant’s self-reported arousal for affective and cognitive messages.
- Compare participant’s self-reported valence for affective and cognitive messages.
- Determine if individual differences – gender, exercise engagement and frequency, self-perception and dieting status – can account for

differences in arousal and valence (measure through psychophysiology and self-report).

- Identify which type of message was more easily recalled.

6.4 Methods

6.4.1 Sample

A total of forty participants (16 males and 24 females, age-range 18-45 years, *M* = 26.8 years, SD = 5.32 years) that met the inclusion criteria (see Chapter 4, section 4.2.2) were recruited for this study. Participants were given £7 on completion as a compensation for their time.

Two electrodermal activity recordings were removed from the analysis. One recording was removed because the participant was a non-EDA respondent. The other recording was removed due to electrode polarization, which resulted in data loss when skin conductance level dropped below the threshold.

Total removed	Participant code (s)	Signal	Removal justification
2	024	EDA	Participant was EDA non-respondent
	025	EDA	EDA electrode polarized, which resulted in loss of data

Table 6.1 Signal exclusion details.

6.4.2 Ethics

The Institute of Psychological Sciences Research Ethics Committee granted ethical approval to conduct this study on 27th June 2014 (see Appendix I). The assigned reference number was 14-0117. Data collection began on 11th July 2014 and finished on 30th September 2014.

6.4.3 Experimental procedure

Before the session

After agreeing to take part in the study participants were invited to attend a single 60-minute session which took place in the Psychophysiology Laboratory. They were asked to refrain from consuming caffeine three hours before the session. Participants met the researcher in the foyer of the Institute of Psychological Sciences.

The session

After being shown to the Psychophysiology laboratory, participants were given the opportunity to ask questions or voice any concerns before the experiment. Once all these were answered to the participant's satisfaction, the consent form was signed. Standard protocols were then followed for site treatments and electrode positioning (see chapter 4, section 4.5.1).

The experimental task took approximately 10 minutes.

The experiment

This study was a computer task requiring participants to read 28 messages (see section 6.4.4) presented in random order; the messages were on screen for 6000-ms. Before and after the message appeared on-screen, a fixation cross was displayed at the centre of the screen for 3000-ms. After reading each message, and after the fixation cross, participants were asked to rate the message they had read for arousal and valence using the Self-Assessment MANIKIN (SAM) developed by Bradley & Lang (1994).

Participants read the following instructions:

Welcome screen

Welcome to the Psychophysiology Laboratory!

Instructions screen 1

Welcome! The experiment is about to begin.

Please avoid moving as much as possible while the experiment is running.

<<Press SPACE to move to the next screen>>

Baseline recording screen

Please relax. This is a 5-minute period to allow you to adjust to the laboratory environment before proceeding with the experiment.

Instructions screen 2

The study being conducted today is investigating how people react to different types of messages. You will see a series of messages on the computer screen; please read each message in your mind. After each one of the messages you will be asked to rate it using a set of figures called SAM.

The first set of figures (valence) shows the happy – unhappy scale, which ranges from a frown to a smile. At one extreme of this scale you are happy, pleased, satisfied, joyful, hopeful or enthusiastic. When you feel completely happy you should indicate this by pressing number 9 on the keyboard. The other end of the scale is for when you feel completely unhappy, annoyed, unsatisfied, melancholic, despaired or bored. You can indicate feeling completely unhappy by pressing number 1.

<<Press SPACE to see the valence scale>>

Valence SAM sample scale screen

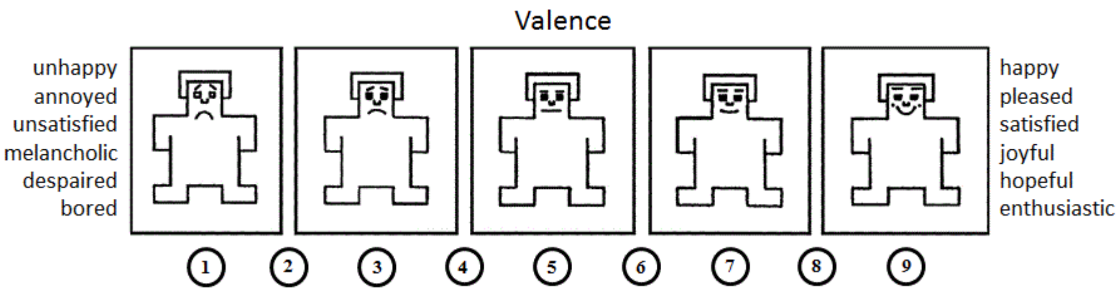

Figure 6.1 The self-assessment MANIKIN for valence.

Instructions screen 3

If you feel completely neutral, neither happy nor sad, press number 5. The figures also allow you to describe intermediate feelings. You can do this by pressing the number that falls between the two figures. This allows you to make more finely graded ratings of how you feel in reaction to the message.

There are a total of 9 possible points along each rating scale from which you can select to indicate the extent to which you felt happy or unhappy.

<<Press SPACE to continue>>

Instructions screen 4

The excited – calm scale (arousal) is the second set of figures you will be using to rate the messages. At one extreme of this scale you are stimulated, excited, frenzied, jittery, wide-awake or aroused. When you feel completely aroused press number 9. At the other extreme you will find the complete opposite feeling. Here you would feel completely calm, unexcited, peaceful, relaxed, sleepy or unaroused. Indicate feeling calm by pressing number 1.

If you are neither excited nor calm press number 5. Again, if you wish to make a more finely tuned rating of how excited or calm you feel, press the number that falls between the figures.

<<Press SPACE to see the arousal scale>>

Arousal SAM sample scale screen

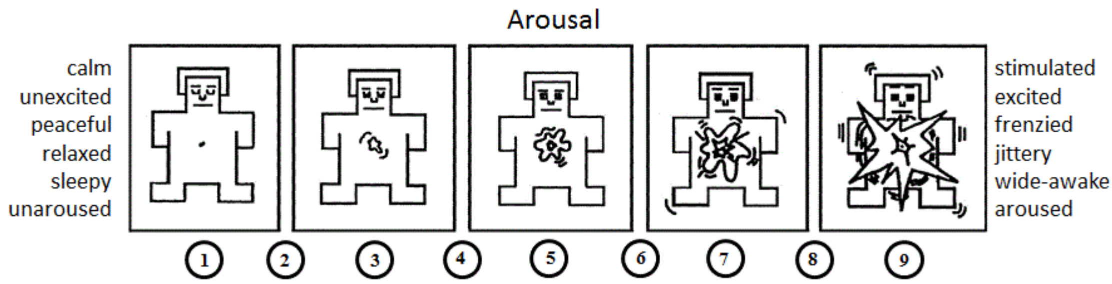

Figure 6.2 The self-assessment MANIKIN for arousal.

Instructions screen 5

In summary, you will see a series of messages displayed on the computer screen. Please read each message in your mind. A fixation cross (+) will appear before and after the message to help you focus your eyes in the centre of the screen. After the fixation cross you will be asked to rate the message using first the happy – unhappy scale (valence) and then the excited – calm scale (arousal).

Please work as fast as you can and do not spend too much time thinking about each message. Rather, make your ratings based on your first and immediate reaction to the message.

Try to be as relaxed as possible and avoid moving as much as possible while we record your biosignals.

<<Press SPACE to go to a practice run>>

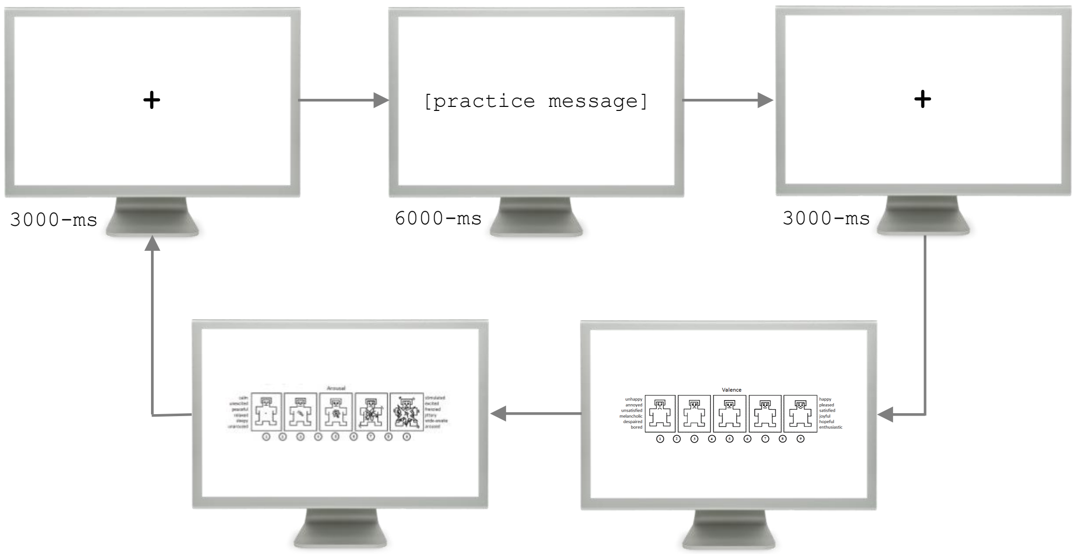

Figure 6.3 Depiction of practice screens.

End of practice screen

End of practice

If there were any questions regarding the experiment they were answered at this point. Participants were reminded to avoid moving as much as possible during the experiment. After a 60-seconds resting period the experiment began.

Experiment screen

> The experiment is about to continue.
>
> Please remember to read each message in your mind. You will rate each message after the fixation cross (+) using first the happy - unhappy scale (valence) and then using the excited – calm scale (arousal).
>
> Remember to work as fast as you can. Make your ratings based on your first and immediate reaction to the message, and avoid moving as much as possible while the experiment is running.
>
> When you are ready to begin press <<SPACE>>

End of experiment screen

> End of experiment

After the experiment

Protocols to verify that the electrodes were still recording properly were followed (see chapter 4, section 4.5.5). Electrodes were removed and a cleansing towel was provided to participants so they could remove any traces of the electrode gel on their face and fingers.

Participants then completed the self-perception and eating behaviours questionnaire. This was followed by a free recall of the text messages in which participants were asked to write down as many messages as they could remember. After they finished the recall task, they were debriefed and given the £7. This concluded the session and participants were escorted to the exit.

After the session

Recordings of electrodermal activity and facial electromyography were cleaned and filtered before extraction (see chapter 4, section 4.5.9). Data regarding stimuli presentation order was extracted from E-Prime and questionnaire data were extracted. Self-reported arousal and valence means for affective and cognitive messages were extracted from the E-Prime data file.

6.4.4 Stimuli

The messages used as stimuli for this study were taken from the study conducted by Sirriyeh et al (2010). This study used a total of 28 messages – 14 affective and 14 cognitive (instrumental) – to increase physical activity. All messages began with: '*Physical activity…'* and ended with the question: '*What activity will you do today?*'

Slight variations of these messages were used in the current study. The opening phrase '*Physical activity…'* was changed for walking, jogging, or swimming to provide participants with some specific activities to think about. The ending question was removed from all messages. Table 6.2 provides the complete list of messages used as stimuli.

Practice messages were taken from the Affective Norms for English Text (ANET) developed and validated by the Centre for the Study of Emotion and Attention of the University of Florida. This large set of brief English text provides ratings of emotion in three dimensions: arousal, valence and dominance (Bradley & Lang, 2007).

Practice Messages[10]

1. You've just won one million pounds; you jump up and down, screaming.
   [Valence: 8.64 Arousal: 8.54]
2. Your car skids wildly; you gasp as you realize you are losing control.
   [Valence: 2.40 Arousal: 8.16]
3. You've been sick all week, lying on a lumpy couch with a bad cold.
   [Valence: 2.15 Arousal: 3.32]
4. You lie lazily in the hammock as a gentle summer breeze rocks you.
   [Valence: 7.77 Arousal: 2.53]
5. You walk through the crowded parking lot, heading for your car.
   [Valence: 5.00 Arousal: 4.47]

Affective Messages

1. Walking can make you feel cheerful.
2. Jogging can make you feel inspired.
3. Swimming can make you feel in a good mood.
4. Walking can make you feel more enthusiastic.
5. Jogging can make you feel empowered.
6. Swimming can make you feel that you can cope with your problems better.
7. Walking can make you feel happier.
8. Jogging can make you feel proud of yourself.
9. Swimming can make you feel more confident.
10. Jogging can make you feel excited.
11. Walking can make you enjoy being with friends.
12. Swimming can make you feel more optimistic.
13. Jogging can make you feel in control over your well-being.
14. Walking can make you feel more positive.

Instrumental Messages

15. Walking can help maintain a healthy weight.
16. Swimming can promote a better night's sleep.
17. Jogging can aid relaxation.
18. Walking can increase your energy levels.
19. Swimming can keep your heart healthy.
20. Jogging can relieve stress.
21. Walking can have many health benefits.
22. Jogging can help maintain a healthy figure.
23. Swimming can help you avoid illness.
24. Walking can help you make friends.
25. Jogging can promote stronger bones.
26. Swimming can help you live a longer active life.
27. Jogging can increase your alertness.
28. Walking can promote stronger muscles.

Table 6.2 List of messages used as stimuli.

[10] Bradley, M. M. & Lang, P. J. (2007). Affective norms for English Text (ANET): Affective ratings of text and instruction manual. Technical report D-1. University of Florida, Gainesville, Fl.

6.5 Statistical analysis

Means for filtered and transformed electrodermal activity and facial electromyography reactivities (see chapter 4, section 4.5.9) were calculated for affective and cognitive messages within participant. Messages' reactivities within participants were then standardised using z-scores Normality was assessed using the Shapiro-Wilk test of normality.

A repeated measures ANOVA was used to test the effect of affective and cognitive messages (see Chapter 4, section 4.5.10).To better understand between-subject interactions, simple contrasts were used.

6.5.1 Arousal and valence of affective and cognitive messages

A repeated measures ANOVA was used to test the effect of affective and cognitive messages on electrodermal activity, facial electromyography, self-reported arousal and self-reported valence.

6.5.2 Individual differences for arousal and valence

A mixed design ANOVA was used to test the effect of the type of message (affective and cognitive) x individual differences (gender, exercise engagement and frequency, self-perception and dieting status) on arousal and valence as measured through psychophysiology and self-reported measures.

6.5.3 Message recall

A repeated measures and mixed design ANOVA was used to test the effect of affective and cognitive messages over recall and recall x individual differences interactions.

6.6 Results

6.6.1 Participants characteristics

The table below summarises the characteristics of the participants that took part in this study.

Participants characteristics	*n* = 40
Age (years), mean (SD)	26.8 (5.32)
Sex	
Males	16 (40%)
Females	24 (60%)
Reported BMI (kg/m^2), mean (SD)	22.56 (3.65)
Dieting status	
Dieting to lose weight	4 (10%)
Dieting or watching as to not put on weight	16 (40%)
Not dieting	20 (50%)
Already engaged in regular exercise	
Yes	32 (80%)
No	8 (20%)
Exercise frequency	
< 3 days a week	13 (32.5%)
3 days a week	12 (30%)
> 3 days a week	13 (32.5%)
failed to report	2 (5%)
Adjusted: people engaged in regular exercise	
Yes	27 (67.5%)
No	13 (32.5%)
Self-perception	
Overweight	13 (32.5%)
About the right weight	21 (52.5%)
Underweight:	6 (15%)

Table 6.3 Participants characteristics.

6.6.2 Arousal of affective and cognitive messages as measured through electrodermal activity

There was no significant effect for the type of message – affective or cognitive (instrumental) – on measured arousal (electrodermal activity); electrodermal activity, $F(1, 37) = 0.028$, $p = 0.868$; early EDA,

$F(1, 37) = 1.674$, $p = 0.204$; late EDA, $F(1, 37) = 0.147$, $p = 0.709$. Electrodermal activity failed to distinguish between the two types of messages.

6.6.3 Valence of affective and cognitive messages as measured through facial electromyography

There was no significant effect for the type of message – affective or cognitive (instrumental) – on valence (facial electromyography); corrugator supercilii, $F(1, 39) = 3.625$, $p = 0.064$; zygomaticus major, $F(1, 39) = 0.833$, $p = 0.367$. Facial electromyography found no difference between the two types of messages.

6.6.4 Self-reported arousal of affective and cognitive messages

There was no effect of the type of message – affective and cognitive – on self-reported arousal, $F(1, 39) = 0.515$, $p = 0.477$. Participants could not identify any difference between the two types of messages in terms of arousal.

6.6.5 Self-reported valence of affective and cognitive messages

There was no significant effect of the type of message over self-reported valence, $F(1, 39) = 0.104$, $p = 0.749$. Again, participants rated themselves no differently on valence after reading affective or cognitive messages.

6.6.6 Individual differences for arousal and valence as measured through psychophysiology

There was a significant main effect on zygomaticus major reactivity by the type of message when dieting status was used as a between-subject factor, $F(1, 37) = 4.486$, $p = 0.041$, $r = 0.33$. Figure 6.4 shows that affective messages elicited a stronger response on zygomaticus major than cognitive messages.

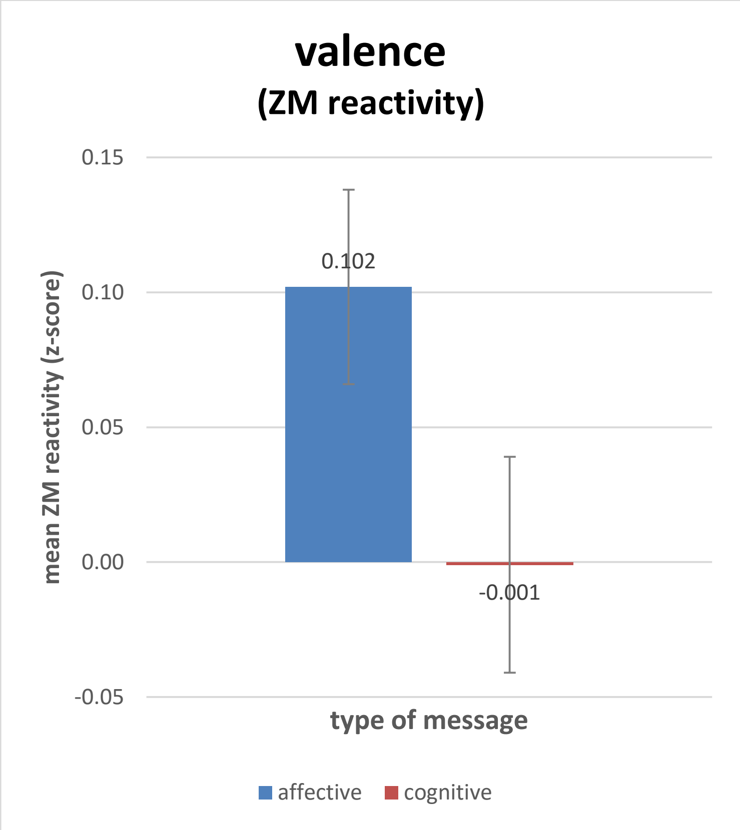

Figure 6.4 The main effect for message type shows that affective messages elicited a stronger response than cognitive messages when measuring activity over zygomaticus major.

The interaction between type of message and dieting status showed a significant effect on zygomaticus major reactivity, $F(2, 37) = 4.5$, $p = 0.018$, $\omega^2 = 0.08$. Figure 6.5 shows that for people dieting to lose weight ($n = 4$) affective messages were perceived as more positive than cognitive messages. However, only 4 participants fell under this category. Cognitive messages were perceived as slightly more positive than affective messages for people dieting or watching what they eat as to not put on weight ($n = 16$). There was no significant change in zygomaticus major reactivity for affective and cognitive messages for people not dieting ($n = 20$). For people not dieting and people dieting or watching wht they eat as to not put on weight, there was no difference in the mean reactivity for affective messages.

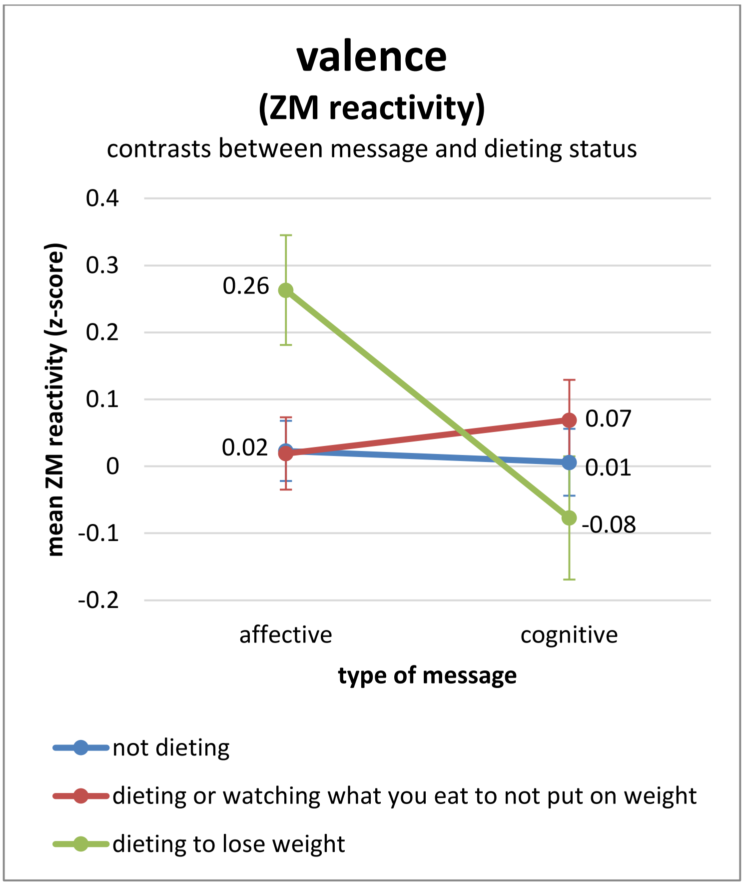

Figure 6.5 Zygomaticus major contrasts for message type x dieting status interaction. This contrast shows no difference in ZM reactivity for affective messages between people reporting not to be dieting and people dieting or watching what they eat.

A repeated measures ANOVA using self-perception (underweight, about the right weight or overweight) as the between-subject factor found a main effect for the message x self-perception interaction, $F(2, 35) = 6.995$, $p = 0.003$, $\omega^2 = 0.16$. Figure 6.6 shows the effect of the type of message over late EDA. People who perceived themselves as about the right weight ($n = 21$) or overweight ($n = 13$) had a more positive late EDA response to affective messages than to cognitive messages. People who perceived themselves as underweight ($n = 6$) had a much stronger late EDA response to cognitive messages than to affective messages. People who perceive themselves as a bout the right weight and overweight reacted to affective and cognitive messages in the same way, with affective messages elicited a more positive late EDA reactivity.

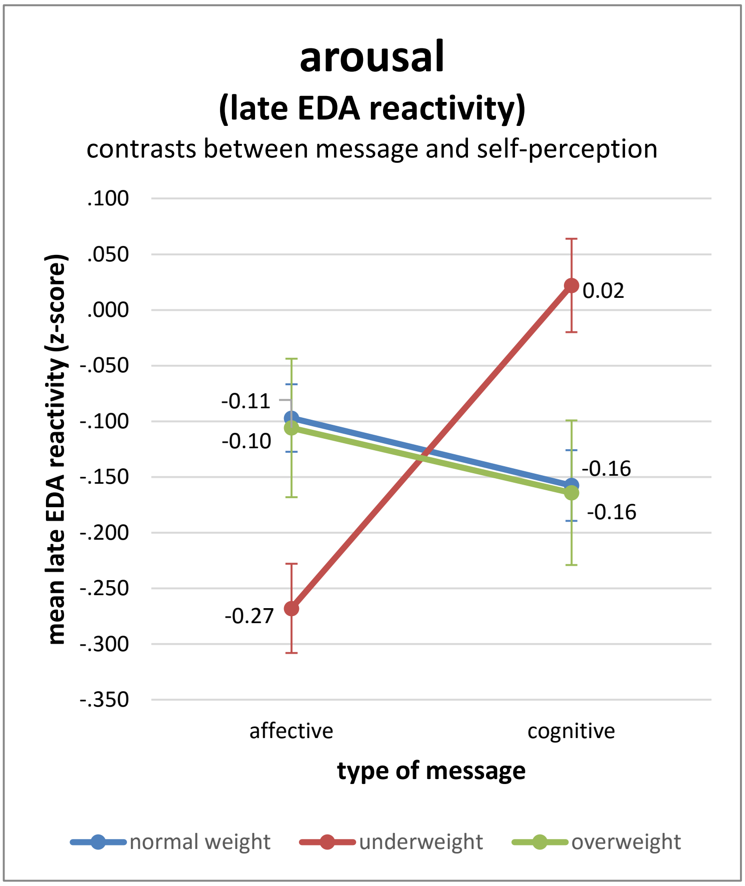

Figure 6.6 Contrasts for late EDA for the interaction message type x self-perception, showing that people who perceived themselves as overweight or of normal weight had a more positive response to affective messages than to cognitive messages.

No other significant interactions were found.

6.6.7 Individual differences for self-reported arousal and valence

A significant interaction between the type of message and exercise engagement was observed for self-reported arousal, $F(1, 38) = 5.108$, $p = 0.03$, r = 0.34. Figure 6.7 shows that people who reported not to be engaged in regular physical activity ($n = 8$) self-reported a higher level of arousal for affective messages than for cognitive messages. People who reported to engage in regular physical activity ($n = 32$) self-reported about the same level of arousal for affective and cognitive messages.

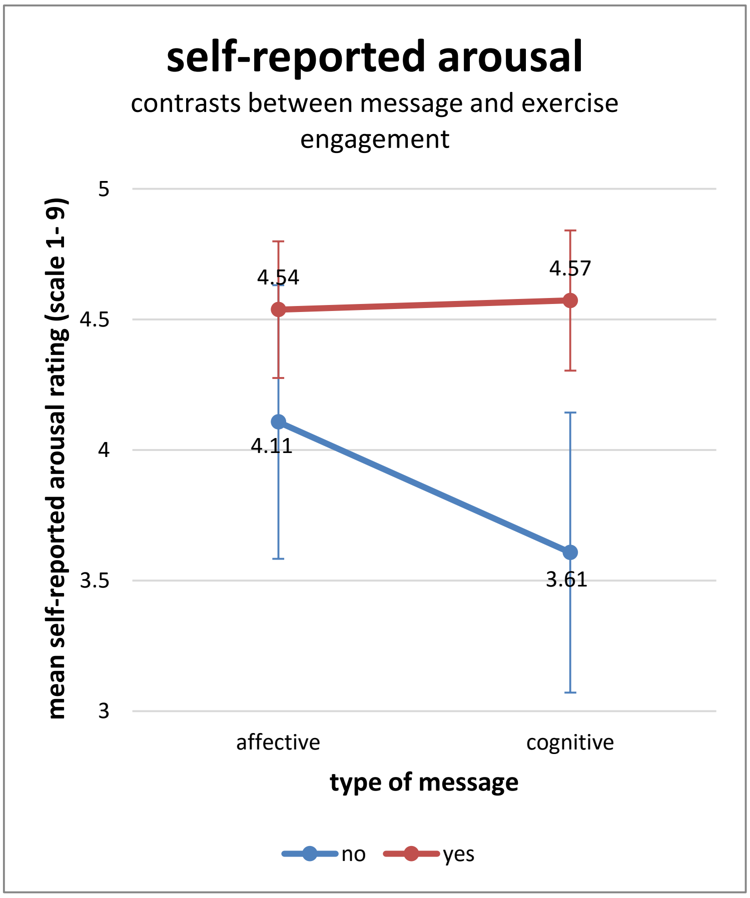

Figure 6.7 Main effects for the message type x exercise engagement interaction, showing that people not engaged in regular physical activity self-reported affective messages as more arousing than cognitive messages.

No other significant interactions were found.

6.6.8 Message recall

There was a significant main effect over the type of message, $F(1, 39) = 20.647$, $p < 0.001$, r = 0.59, on recall. Participants recalled a mean of 1.75 affective messages (SD = 1.24), while almost double this number was recalled for cognitive messages ($M = 3.25$, SD = 1.88), as can be seen in Figure 6.8.

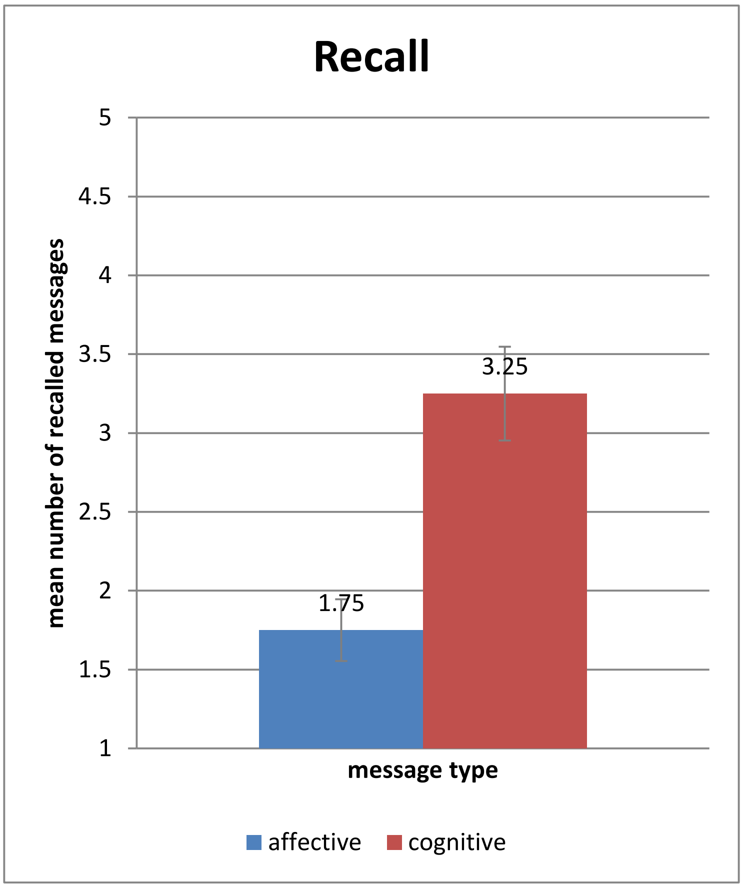

Figure 6.8 Cognitive messages were more easily recalled than affective messages, almost twice as much.

There were no other significant interactions for recall between the type of message and individual differences.

6.7 Discussion

6.7.1 Arousal and valence

Sirriyeh et al. (2010) showed in a 2-weeks study that affective messages are more effective than cognitive messages for making people more physically activity. It was therefore hypothesized that affective messages would be perceived as more positive than cognitive messages and that affective messages would elicit higher arousal. However, the present study, surprisingly, found no effect of the type of message (affective or cognitive) over arousal or valence as measured through psychophysiology (electrodermal activity and facial electromyography) or self-reported measures.

Morris et al. (2015) demonstrated that affective and cognitive messages framed in terms of short and long term consequences had different effects on self-reported physical activity. Affective short term and cognitive long term messages were found to be equally effective at increasing self-reported physical activity. The messages used by Sirriyeh et al. (2010) seem to be framed in terms of short (affective) and long term (cognitive) gains. This could explain why there was no difference in arousal and valence. All messages evaluated by Morris et al. (2015) started with the statements: '*In the long term…*' or '*In the short term…*' (e.g. In the short term exercise can reduce muscular tension and enhance concentration and energy levels, making you feel immediately happy with life.). This wording, however, was not present in Sirriyeh et al.'s (2010) study.

Affective messages used affective words such as cheerful, excited and optimistic. However, self-reported arousal for these words, as taken from the ANEW list, shows that these words are not particularly perceived as arousing by people, but closer to neutral arousal; they are perceived as positive words in terms of valence, though. This could explain the absence of an affective physiological response to these words.

6.7.2 Individual differences

Sirriyeh et al. (2010) conducted a secondary analysis on their data and found that there was no longer a significant main effect of the condition in individuals who were already engaged in physical activity. Thirty two participants in this study reported to be engaged in regular physical activity. When electrodermal activity was analysed using reported exercise engagement as a between subject factor no significant effect was found.

On the other hand, when self-reported arousal was analysed using reported engagement in physical activity as a between-subject factor, a statistical significant difference was found between the two types of messages with a medium size effect ($r = 0.34$). Affective messages were rated higher than cognitive messages by those participants who reported not being engaged in physical activity. Participants who reported engagement in physical activity rated both types of messages very similarly.

The zygomaticus major results for the type of message and dieting status interaction showed a medium effect size ($\omega^2 = 0.08$). However, only four people reported to be currently dieting to lose weight. Late EDA found a large effect size ($\omega^2 = 0.16$) for the type of message and self-perception interaction.

6.7.3 Message recall

Surprisingly, more cognitive messages were recalled compared to affective messages. The size effect for this difference was large, $d = 0.8$. A study conducted by Kensinger & Corkin (2003) found that recall rates were higher for stimuli with valence or arousal compared to neutral stimuli, and the effect was higher for arousal only compared to valence only stimuli. A number of studies have demonstrated that arousal and valence play an important role on recall and memory (Gomes et al., 2012; Newell, Henderson, & Wu, 2001; Sharot & Phelps, 2004). Affective messages failed to elicit overall strong levels of arousal and valence than cognitive messages. This could explain why they were not more easily remembered.

6.7.4 Limitations

Results from this study should be considered according to the following limitations. The messages used for this study were taken from the study run by Sirriyeh et al. (2010). This library consisted of only 28 messages (14 affective and 14 cognitive). All the messages had the same structure and the differences between them were minimal. Although this research had access to other libraries, this was the only library that focused only on one behaviour: physical activity. Other libraries included other behaviours such as dieting, exercising and self-monitoring.

Although the results of this study are limited by the selected text message library, this was still the best available library. Also, this library demonstrated that physical activity was increased by affective messages over results from cognitive messages.

However, these text messages were only evaluated for two weeks, and the long–term effects of the messages are unknown. Results from Sirriyeh et al's (2010) study were based on self-reported physical activity and no objective measure was used to determine the amount of physical activity done by participants. This could have introduced sources of bias, such as over reporting, lack of precision and social desirability, as acknowledged by the authors of the study.

Participant recruitment was not based on their engagement in exercise. Results from the original study found no significant effect of the condition for people already active, but a significant effect of condition was demonstrated for inactive participants; participants receiving affective messages increased their levels of physical activity (471.1 MET minutes per inactive participant). Recruitment based on exercise engagement could have shown effects on both affective and cognitive messages.

6.8 Summary

Psychophysiology detected no main effects of arousal and valence as for affective and cognitive messages, nor were any apparent in self-reported measures of arousal and valence. These methods failed to differentiate between the two types of messages. Surprisingly, more cognitive messages were recalled by participants.

The next chapter explores the effect of personalisation over arousal and valence (measured again using psychophysiology and self-report) in an attempt to increase arousal and valence. Perceived message persuasiveness will also be assessed through self-report.

Chapter 7:

The effect of personalisation of affective and cognitive messages on arousal and valence, and message recall

Chapter 7: The effect of personalisation of affective and cognitive messages on arousal and valence, and message recall

7.1 Overview

This chapter investigated the effect of message personalisation on electrodermal activity and facial electromyography, and self-reported arousal, valence and persuasiveness. Personalisation strategies included identification and contextualisation. Affective and cognitive messages used in the study presented in the previous chapter were now personalised using participant's preferred physical activity, participant's name, participant's name and preferred physical activity, and control (no personalisation).

7.2 Introduction

Systematic reviews have identified personalisation and tailoring as an important component of mHealth interventions (Cole-Lewis & Kershaw, 2010; Fjeldsoe et al., 2009; Hall et al., 2015). Message tailoring and personalisation have been associated with greater intervention efficacy and effect sizes (Head et al., 2013; Napolitano & Marcus, 2002).

Tailoring is used to refer to any number of methods used to create individualised communications for their receivers, with the expectation that this individualisation will lead to larger intended effects of this communication (Hawkins et al., 2008). Tailored communication aims to reach one specific individual based on specific characteristics of that person (Kreuter & Wray, 2003).

Hawkins et al. (2008) propose three distinct tailoring strategies: personalisation, feedback and content matching; the three of the most common personalisation tactics are: identification, raising expectation and contextualisation.

Although research has found that affective text messages are more effective than cognitive messages for increasing physical activity in behaviour change interventions (Morris et al., 2015; Sirriyeh et al., 2010), study 2 of this research (presented in Chapter 6) found no significant differences between these two types of messages for electrodermal activity and self-reported arousal (EDA), and facial electromyography over corrugator supercilii and zygomaticus major, and self-reported valence.

Messages used in Chapter 6 were not particularly personalised to individuals, although some messages may have felt like that for certain participants. Personalisation of messages through identification and contextualisation may be a useful way of increasing levels of arousal and valence, and, thus, increase message effectiveness to reach people.

7.3 Aim and objectives

The study aim was to measure and compare the effects of personalisation of affective and cognitive messages - using participant's preferred physical activity and name - on electrodermal activity, facial electromyography, self-reported arousal and valence, and recall.

Messages were manipulated to test four different levels of personalisation: only incorporating participant's preferred physical activity, only incorporating participant's name, incorporating participant's name and preferred physical activity, and neither (control).

The objectives of this study were to:

- Compare electrodermal activity between type of message (affective or cognitive) and personalisation.
- Compare facial electromyography over corrugator supercilii and zygomaticus major between affective and cognitive messages, and personalisation.
- Compare self-reported arousal and valence between type of message and personalisation.
- Compare self-reported persuasiveness between the two types of messages and their personalisation.
- Determine if individual differences – exercise engagement and frequency, self-perception, or dieting status – can account for differences in electrodermal activity, facial electromyography, self-reported arousal and valence, and self-reported persuasiveness.
- Identify the most memorable message type and personalisation strategy through recall.

7.4 Methods

This study was a 2 (type of message: affective or instrumental) x 4 (personalisation strategy: preferred physical activity, participant's name, participant's name and preferred physical activity, or control) mixed design (within and between subject factors).

7.4.1 Sample

Forty two participants (14 males and 28 females, age-range 18-45 years, *M* = 28.1 years, SD = 6.23 years) meeting the inclusion criteria (see Chapter 4, section 4.2.2) took part in the study. They received £7 as remuneration for their time.

No recordings were removed from the analysis.

7.4.2 Ethics

The Institute of Psychological Sciences Research Ethics Committee gave favourable ethical approval on the 21st October 2014 (see Appendix I). The reference number for this study was 14-0198. Data collection took place from 27th October 2014 to 30th January 2015.

7.4.3 Experimental procedure

Before the session

Participants who agreed to take part in the study attended a single 60-minute session at the Psychophysiology Laboratory. Participants refrained from consuming coffee three hours before the session. A short questionnaire entitled 'About you and exercise' (see Appendix J) was sent to participants with the confirmation email. This questionnaire asked participants three things: 1) if they were currently engaged in physical activity, 2) if so, how frequently they engaged in physical activity, and, 3) from a list of options, to order which type of physical activity/exercise they were already engaged in doing or would enjoy doing. The questionnaire was returned before the session via email to the researcher and information from the questionnaire was used to personalise the messages.

The session

After meeting the researcher in the foyer of the Institute of Psychological Sciences, participants were guided to the laboratory. Once in the laboratory, questions and/or concerns were addressed to participant's satisfaction, and then the participant consent form was signed. This was followed by the recording sites preparation (washing hands and cleaning face), and electrode attachment (see Chapter 4, section 4.5.2 for details).

The experiment

Participants were required to read a total of 28 messages, some of which had been personalised using participant's preferred physical activity, participant's name, or participant's name and preferred physical activity. Control messages included randomly selected physical activities that were not among the participant's favourites. These activities were taken from the "About you and exercise" questionnaire.

Messages appeared on-screen for 6000-ms and were followed by a fixation cross (3000-ms on-screen). They were then asked to rate the message they had just read in terms of arousal, valence and how likely would it be for them to engage in physical activity after reading it. Self-reported arousal and valence were measured using the Self-Assessment MANIKIN (SAM) developed by Bradley & Lang (1994). The persuasiveness scale used the same scale (1-9) as the arousal and valence scales.

These instructions were given to the participants:

Welcome screen

`Welcome to the Psychophysiology Laboratory!`

Instructions screen 1

```
Welcome! The experiment is about to begin.

Please avoid moving as much as possible while the
experiment is running.

          <<Press SPACE move to the next screen>>
```

Baseline recording screen

Please relax. This is a 5-minute period to allow you to adjust to the laboratory environment before proceeding with the experiment.

Instructions screen 2

The study being conducted today is investigating how people react to different types of messages. You will see a series of messages on the computer screen; please read each message silently to yourself. After each message you will be asked to rate it for valence (pleasure), arousal and persuasiveness. All three ratings use a set of figures called SAM.

The first set of figures that you will be presented with shows the happy – unhappy scale (valence), which ranges from a frown to a smile. At one extreme of this scale you are happy, pleased, satisfied, joyful, hopeful or enthusiastic. If you feel completely happy you should indicate this by pressing number 9 on the keyboard. The other end of the scale is for when you feel completely unhappy, annoyed, unsatisfied, melancholic, despaired or bored. You can indicate feeling completely unhappy by pressing number 1.

<<Press SPACE to see the valence scale>>

Valence SAM sample scale screen

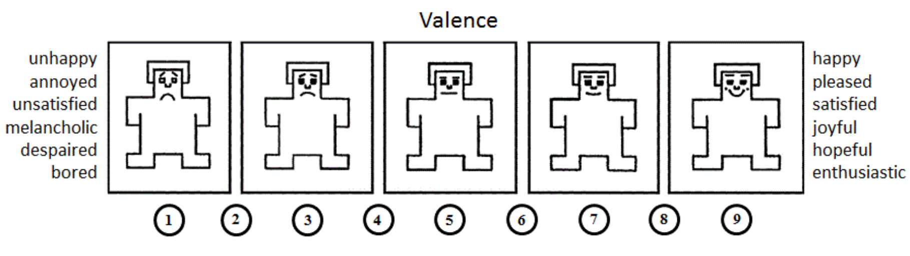

Figure 7.1 The self-assessment MANIKIN for valence.

Instructions screen 3

If you feel completely neutral, neither happy nor sad, press number 5. The figures also allow you to describe intermediate feelings. You can do this by pressing the number that falls between the two figures. This allows you to make more finely graded ratings of how you feel in reaction to the message.
There are a total of 9 possible points along each rating scale from which you can select to indicate the extent to which you feel happy or unhappy.

<<Press SPACE to continue>>

Instructions screen 4

The excited – calm scale (arousal) uses a second set of figures for rating the message. At one extreme of this scale you would be stimulated, excited, frenzied, jittery, wide-awake or aroused. If you feel completely aroused press number 9. At the other extreme you will find the completely opposite feeling. Here you would feel completely calm, unexcited, peaceful, relaxed, sleepy or unaroused. Indicate feeling completely calm by pressing number 1.

If you are neither excited nor calm press number 5. Again, if you wish to make a more finely tuned rating of how excited or calm you feel, press the number that falls between the figures.

<<Press SPACE to see the arousal scale>>

Arousal SAM sample scale screen

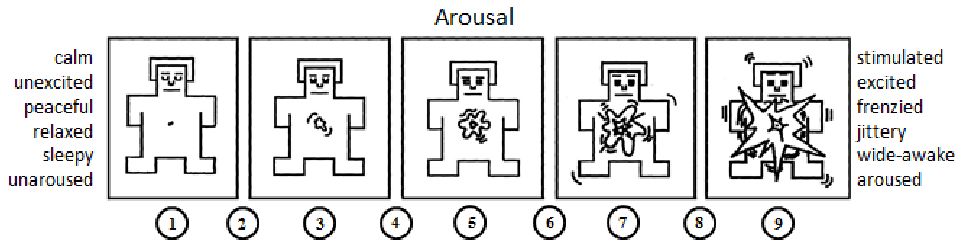

Figure 7.2 The self-assessment MANIKIN for arousal.

Instructions screen 5

Finally, you will be asked about how persuasive the message is by responding to the question: "For me to engage in physical activity after reading this message would be:" At one extreme of this scale the message would not motivate you, making it very unlikely for you to engage in physical activity after reading the message. At the other extreme of the scale the message will very likely motivate you to engage in physical activity.

Press number 5 in case of feeling neutral about this (neither unlikely nor likely). A more finely tuned rating can be given by pressing a number that falls between the figures.

<<Press SPACE to see the scale>>

Persuasiveness sample scale screen

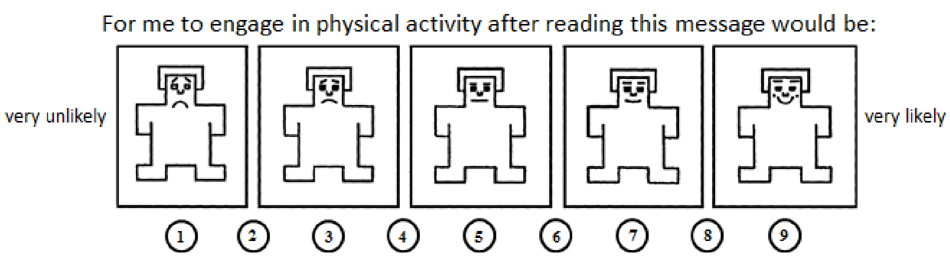

Figure 7.3 Adapted self-assessment MANIKIN for engagement in physical activity.

Instructions screen 6

In summary, you will see a series of messages one by one displayed on the computer screen. Please read each message in your mind. A fixation cross (+) will appear before and after the message to help you focus your eyes in the centre of the screen. After it you will be asked to rate the message using, first, the happy – unhappy scale (valence), then the excited – calm scale (arousal) and, finally, you will be asked how likely it would be for you to engage in physical activity after reading the message.

Do not spend too much time thinking about each message. Rather, make your ratings based on your first and immediate reaction to the message.

Try to be as relaxed as possible and, please, avoid moving as much as possible while the message is displayed on the computer screen.

<<Press SPACE to go to a practice run>>

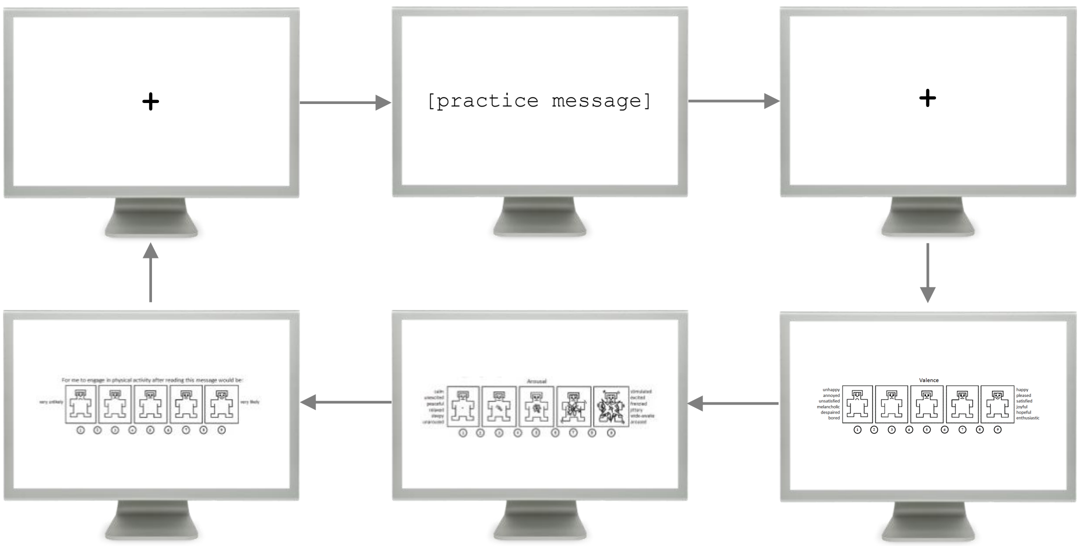

Figure 7.4 Depiction of practice trial screens.

End of practice screen

End of practice

At this point, participants were asked if they had any questions regarding the experiment. Questions, if any, were answered to the participant's satisfaction. They were reminded to avoid moving as much as possible during the stimulus presentation. Finally, they were told that after a 60-seconds resting period the experiment will begin.

Experiment screen

> The experiment is about to begin.
>
> Please remember to read each message quietly to yourself. You will rate each message after the fixation cross (+) using first the happy – unhappy scale (valence), then using the excited – calm scale (arousal) and, finally, its persuasiveness.
>
> Remember to make your ratings based on your first and immediate reaction to the message, and avoid moving as much as possible.
>
> When you are ready to begin, press <<SPACE>>

End of experiment screen

> End of experiment

After the experiment

Electrodes were tested again asking participants to frown, smile and hold their breath (see Chapter 4, section 4.5.5 for more details). Protocols for electrode removal were then followed (see Chapter 4, section 4.5.6). Following electrode removal, participants were handed the self-perception and eating behaviours questionnaire and then completed the recall task. Finally, participants were debriefed, given £7, thanked again for their time and escorted to the exit.

After the session

Physiological data was cleaned, filtered and transformed (see Chapter 4, section 4.4.9). Questionnaire data were extracted, and data on stimuli presentation order and self-reported scores for arousal, valence and persuasiveness were extracted from E-Prime.

7.4.4 Stimuli

Messages from Sirriyeh et al.'s (2010) study were personalised. These 28 messages were randomly personalised, but special care was taken to ensure that throughout the study all messages were personalised equally using the 4 personalisation strategies. This was done to prevent that some messages were personalised more frequently using only one or two personalisation strategies throughout the study. Personalisation strategies for the messages included: participant’s preferred physical activity, participant’s name, or participant’s name and preferred physical activity. Information about participant’s preferences for physical activity was obtained prior the session to personalise the messages.

The same calibration/practice messages used for study 2 were used for this study (see Chapter 6, section 6.4.3 to see the calibration messages).

7.5 Statistical analysis

Means of filtered and transformed physiological responses were used to calculate reactivities (see chapter 4, section 4.5.9). Reactivities were standardised within participant using z-scores

Repeated measures ANOVAs were used to test for the effect of the type of messages x personalisation within and between subjects (see Chapter 4, section 4.5.10). Simple contrasts were used to better understand interactions within subject variables and between-subject factors.

7.5.1 Arousal and valence as measured through psychophysiology and self-report measures, and self-reported persuasiveness

A repeated measures ANOVA was conducted to test for the effect of type of message (affective or cognitive) x personalisation (preferred physical activity, name, preferred physical activity + name, control).

7.5.2 Individual differences for arousal and valence as measured through psychophysiology and self-report, and self-reported persuasiveness.

A mixed design ANOVA was conducted to test for the effect of type of message (affective or cognitive) x personalisation (participant’s preferred physical activity, participant's name, participant's preferred physical activity and name, control) over measured and self-reported arousal and valence.

7.5.3 Message recall

A repeated measures ANOVA was conducted to test for the effect of the personalisation over recall.

7.6 Results

7.6.1 Participants characteristics

Participants characteristics	*n* = 42
Age (years), mean (SD)	28.1 (6.23)
Sex	
Males	14
Females	28
BMI (kg/m^2)	22.1 (2.7)
Dieting status	
Dieting to lose weight	3 (7%)
Dieting or watching as to not put on weight	19 (45.2%)
Not dieting	20 (47.6%)
Already engaged in regular exercise	
Yes	27 (64.3%)
No	15 (35.7%)
Exercise frequency	
< 3 days a week	20 (47.6%)
3 days a week	11 (26.2%)
> 3 days a week	11 (26.2%)
Adjusted: people engaged in regular exercise	
Yes	22 (52.4%)
No	20 (47.6%)

Table 7.1 Participants characteristics.

Participants characteristics		*n* = 42
Self-perception		
Overweight		18 (42.9%)
About the right weight		16 (38.1%)
Underweight:		7 (16.7%)
	failed to report	1 (2.4%)

Table 7.1 Participants characteristics (contd.).

7.6.2 Arousal as measured through electrodermal activity

There were no significant effects for the type of message on electrodermal activity, $F(1, 41) = 0.331$, $p = 0.568$, early EDA, $F(1, 41) = 0.235$, $p = 0.630$, late EDA, $F(1, 41) = 0.158$, $p = 0.693$.

Maulchy's test indicated that the assumption of sphericity had been violated for the main effects of personalisation for early EDA, $\chi^2(5) = 16.188$, $p = 0.006$, and late EDA, $\chi^2(5)= 11.298$, $p = 0.046$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.822$ for early EDA, and $\varepsilon = 0.853$ for late EDA for the main effect of personalisation).

No effect of personalisation on electrodermal activity were found, electrodermal activity, $F(3, 123) = 0327$, $p = 0.806$, early EDA, $F(2.465, 101.073) = 0.398$, $p = 0.715$, late EDA $(2.558, 104.873) = 0.616$, $p = 0.581$.

Maulchy's test indicated that the assumption of sphericity had been violated for the main effects of message x personalisation for electrodermal activity, $\chi^2(5)= 21.252$, $p = 0.001$, for early EDA, $\chi^2(5)= 19.868$, $p = 0.001$, and for late EDA, $\chi^2(5)= 22.226$, $p < 0.001$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.723$ for electrodermal activity, $\varepsilon = 0.778$ for early EDA, and $\varepsilon = 0.723$ for late EDA for the main effect of message x personalisation).

No effect of the message x personalisation interaction for arousal measured through electrodermal activity was found, electrodermal activity, $F(2.168, 88.905) = 0.014$, $p = 0.990$, early EDA, $F(2.334, 95.707) = 0.648$, $p = 0.549$, late EDA, $F(2.168, 88.908) = 0.179$, $p = 0.853$.

7.6.3 Valence as measured through facial electromyography

There were no significant effects for the type of message, $F(1, 41) = 0.942$, $p = 0.337$, personalisation, $F(3, 123) = 0.781$, $p = 0.507$, and message x personalisation, $F(3, 123) = 0.581$, $p = 0.629$, on corrugator supercilii.

No significant effects of the type of message were found for zygomaticus major, $F(1, 41) = 0.011$, $p = 0.916$.

There was a significant main effect for the personalisation of messages on zygomaticus major, $F(3, 123) = 3.970$, $p = 0.010$. Contrasts revealed that personalisation including participant's preferred physical activity was significantly more positive than control messages, $F(1, 41) = 4.175$, $p = 0.047$, r = 0.3, and participant's name paired with participant's preferred physical activity were also significantly positive when compared to the control messages, $F(1, 41) = 15.556$, $p < 0.001$, r = 0.52 (see Figure 7.5).

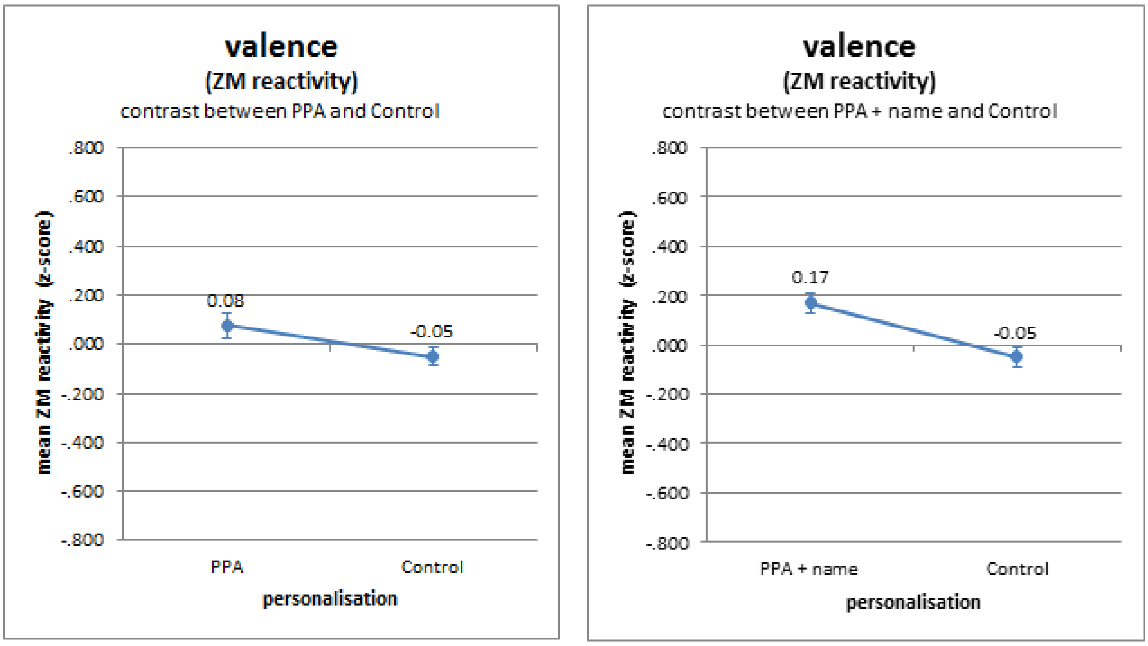

Figure 7.5 Contrasts for the main effect of personalisation on zygomaticus major reactivity, showing that messages that included PPA and PPA + name elicited a stronger response than control messages.

Maulchy's test indicated that the assumption of sphericity had been violated for the main effects of message x personalisation for zygomaticus major, $\chi^2(5) = 12.098$, $p = 0.034$. No effects were found for this interaction on zygomaticus major, $F(2.552, 104.615) = 0.277$, $p = 0.81$.

7.6.4 Self-reported arousal

No effect of the type of message on self-reported arousal was found, $F(1, 41) = 0.913$, $p = 0.345$. No effect was found for the message x personalisation interaction, $F(3, 123) = 0.955$, $p = 0.416$.

Maulchy's test indicated that the assumption of sphericity had been violated for the main effects of personalisation on self-reported arousal, $\chi^2(5) = 13.869$, $p = 0.016$. Degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.779$ for self-reported arousal for the main effect of personalisation). A significant main effect of personalisation on self-reported arousal was found, $F(2.392, 98.070) = 22.311$, $p < 0.001$.

Contrasts revealed that messages including participant's preferred physical activity were significantly more arousing than control messages, $F(1, 41) = 33.175$, $p < 0.001$, r = 0.67; and messages personalised using participant's preferred physical activity + Name were more arousing than control messages, $F(1, 41) = 32.207$, $p < 0.001$, r = 0.66 (see Figure 7.6).

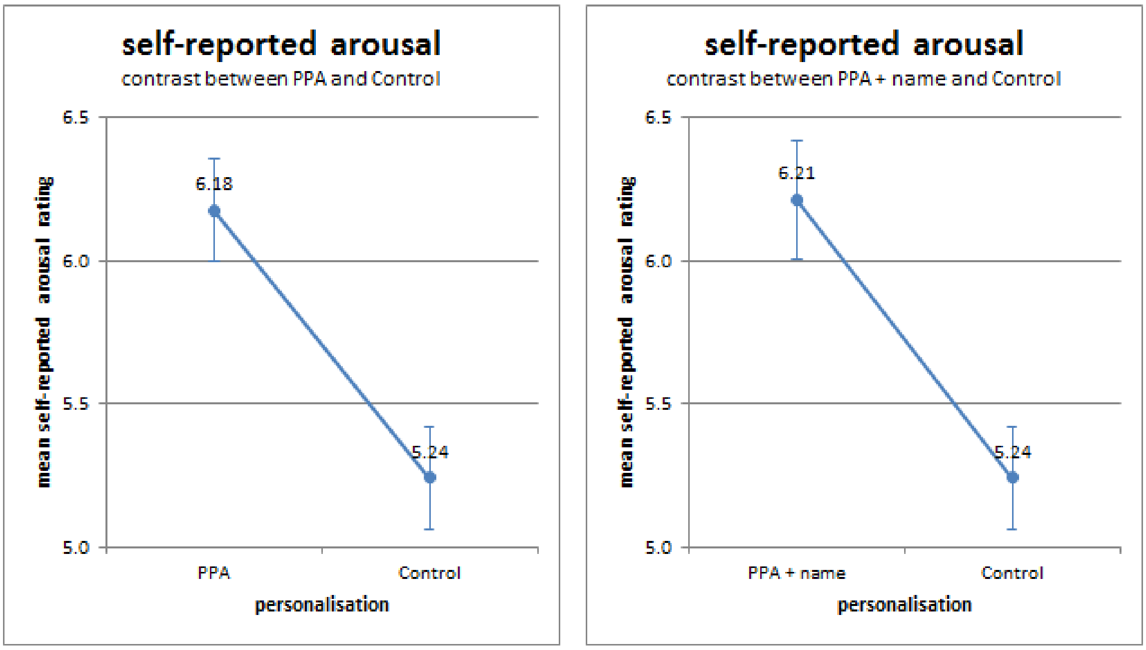

Figure 7.6 Contrasts for the main effect of personalisation on self-reported arousal. Messages that included PPA as personalisation tactic were self-reported as more arousing than control messages.

7.6.5 Self-reported valence

No effect of the type of message on self-reported valence was found, $F(1, 41) = 0.729$, $p = 0.398$. No effect was found for the message x personalisation interaction, $F(3, 123) = 1.734$, $p = 0.163$.

A significant main effect of personalisation on self-reported valence was found, $F(3, 123) = 26.970$, $p < 0.001$.

Contrasts revealed that personalisation using participant's preferred physical activity was perceived significantly more positive than control messages, $F(1, 41) = 34.391$, $p < 0.001$, r = 0.68. Messages including participant's preferred physical activity + Name were perceived more positively than control messages, $F(1, 41) = 55.072$, $p < 0.001$, r = 0.76 (see Figure 7.7).

Figure 7.7 Contrasts for the main effect of personalisation on self-reported valence. Messages personalised using PPA and PPA + name were self-reported as more positive than control messages.

7.6.6 Self-reported persuasiveness

No effect was found for the type of message on self-reported persuasiveness, $F(1, 41) = 2.189$, $p = 0.147$.

Maulchy's test indicated that the assumption of sphericity had been violated for the main effects of personalisation, $\chi^2(5) = 20.002$, $p = 0.001$. Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom ($\varepsilon = 0.738$). There was a significant main effect of personalisation on self-reported persuasiveness, $F(2.214, 90.756) = 41.037$, $p < 0.001$.

Contrasts revealed that personalisation strategies including participant's preferred physical activity were rated as significantly more persuasive than the control messages, $F(1, 41) = 54.813$, $p < 0.001$, r = 0.76; and messages that included participant's preferred physical activity + Name were also more persuasive than control messages, $F(1, 41) = 73.492$, $p < 0.001$, r = 0.80 (see Figure 7.8).

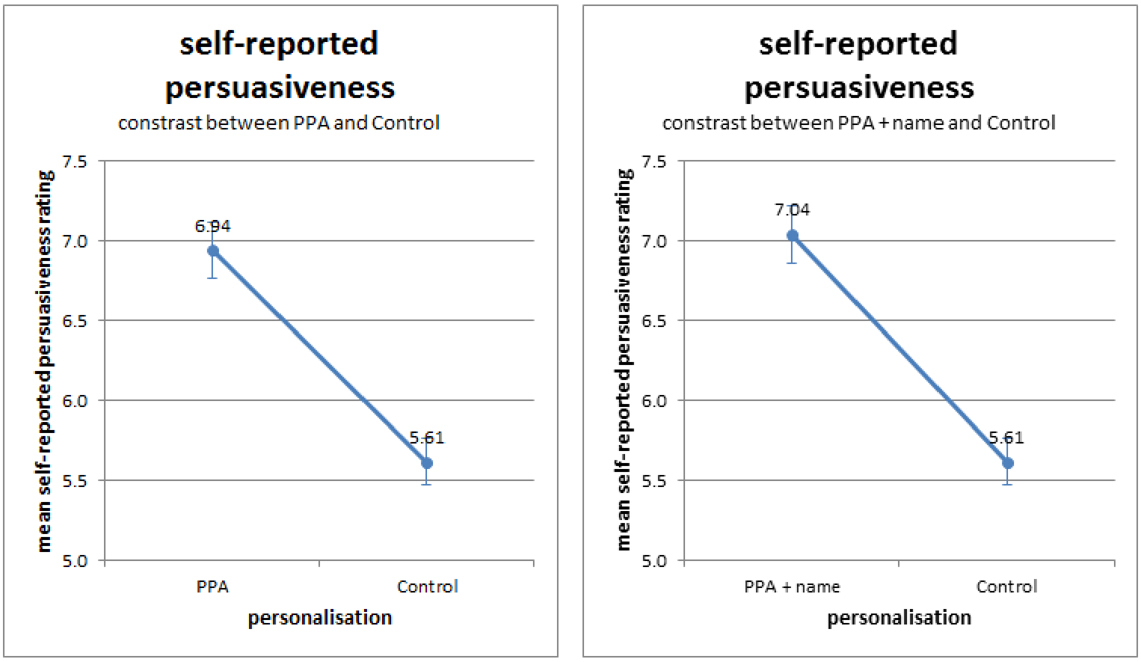

Figure 7.8 Contrasts for the main effect of personalisation on self-reported persuasiveness. Personalised messages using PPA and PPA + name as personalisation tactics were self-reported by participants as more persuasive than control messages.

A significant main effect for the interaction of message x personalisation was found, $F(3, 123) = 2.796$, $p = 0.043$.

Contrasts showed that messages including participant's preferred physical activity were rated as more persuasive when compared to control messages for both types of messages (affective and cognitive), $F(1, 41) = 6.290$, $p = 0.016$, $r = 0.36$. A difference between affective and cognitive messages can be seen in Figure 7.9 for the control messages, showing that cognitive control messages are perceived as more persuasive than affective messages. The same was found for messages that included participant's preferred physical activity + Name when compared to control, being cognitive control messages perceived as more persuasive than affective control messages, $F(1, 41) = 4.529$, $p = 0.039$, $r = 0.32$. Affective and cognitive messages that were personalised using participant's preferred physical activity and participant's preferred physical activity + Name did not differ between them in participant's self-reported persuasiveness.

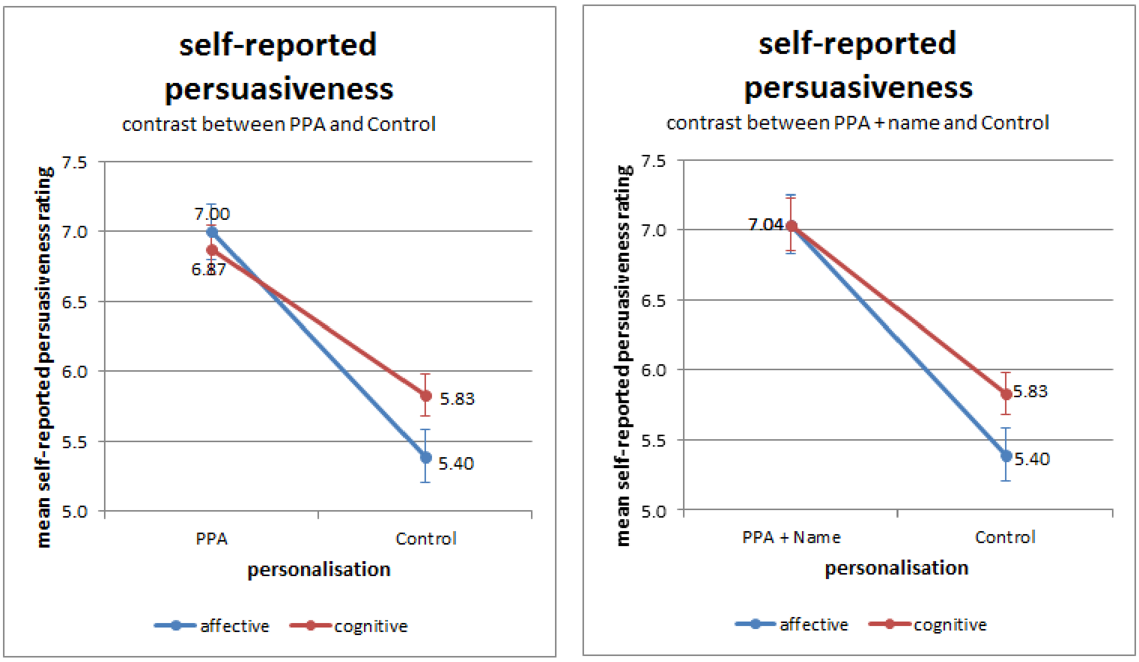

Figure 7.9 Contrasts for the main effect of message x personalisation interaction on self-reported persuasiveness. No difference in self-reported persuasiveness was found between affective and cognitive messages for messages personalised using PPA or PPA + Name.

7.6.7 Individual differences

Electrodermal activity and facial electromyography

There was a significant interaction between the type of message x personalisation x exercise on electrodermal activity, early EDA and late EDA. Maulchy's test showed that sphericity had been violated, $\chi^2(5) = 20.059$, $p = 0.001$ for electrodermal activity, $\chi^2(5) = 20.172$, $p = 0.01$ for early EDA, and $\chi^2(5) = 17.695$, $p = 0.03$ for late EDA. Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom for electrodermal activity, early EDA, and late EDA ($\varepsilon = 0.732$, $\varepsilon = 0.755$, and $\varepsilon = 0.759$, respectively), electrodermal activity, $F(2.195, 87.783) = 4.730$, $p = 0.009$, early EDA, $F(2.265, 90.595) = 4.420$, $p = 0.012$, and late EDA, $F(2.277, 91.060) = 4.455$, $p = 0.011$.

Contrasts showed that electrodermal activity reactivity for people who reported not to exercise was different from electrodermal activity reactivity for people who reported to exercise, $F(1, 40) = 6.108$, $p = 0.018$, r = 0.36. Figure 7.10 shows that, for people who reported not to exercise ($n = 15$), personalised affective messages using participant's name elicited no electrodermal activity reactivity when compared to control messages; however, cognitive messages that did not contain participant's name elicited a change in electrodermal activity. For people who reported themselves as regularly engaging in exercise ($n = 27$), cognitive messages elicited a stronger electrodermal activity reactivity for those messages containing participant's name when compared to control messages. The opposite effect happened for affective messages.

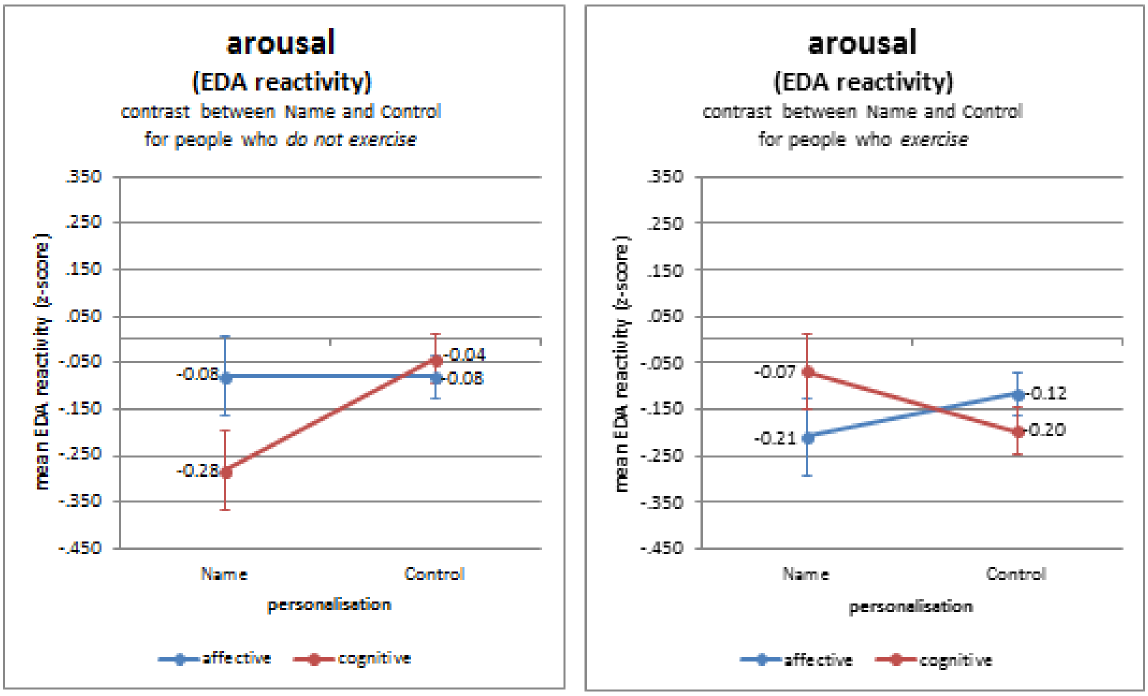

Figure 7.10 Contrasts for the message x personalisation x exercise engagement interaction on electrodermal activity showing that people not engaged in exercise affective messages containing their name had no effect.

Contrasts showed the same effect for early EDA, $F(1, 40) = 7.191$, $p = 0.011$, r = 0.39. Figure 7.11 shows the contrasts for the message x personalisation x exercise interaction.

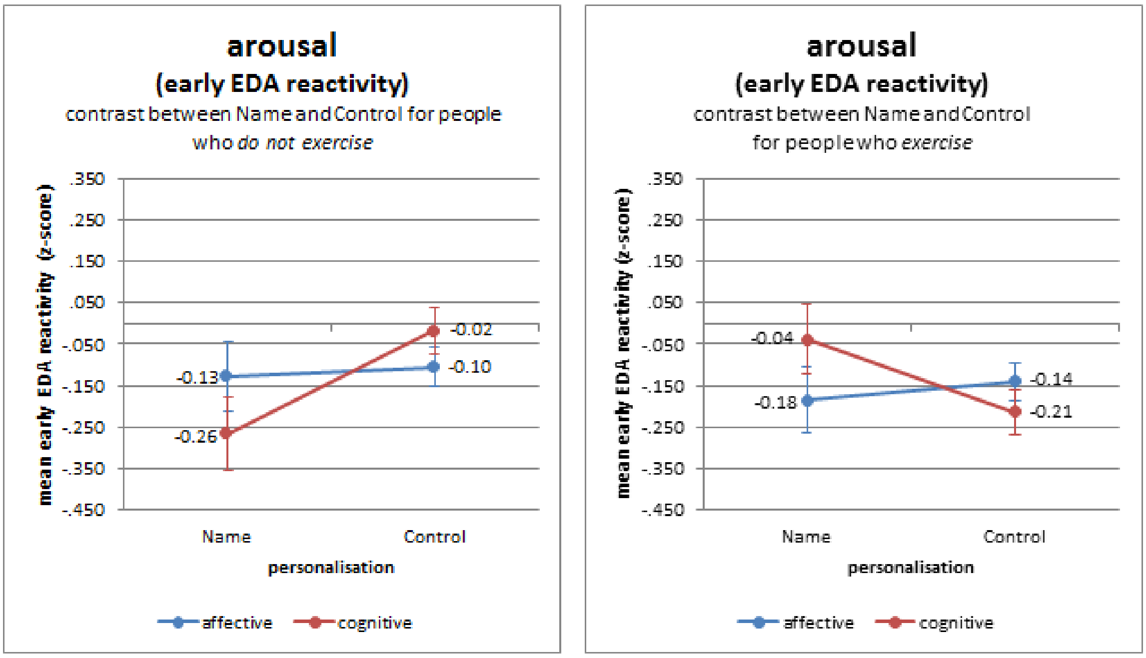

Figure 7.11 Contrasts for the message x personalisation x exercise engagement interaction on early EDA showing that affective messages containing participant's name had almost no effect.

Contrasts showed, however, no significant interactions for late EDA.

A significant interaction was also found for the message x personalisation x exercise frequency on electrodermal activity, early EDA, and late EDA. The assumption of sphericity was violated for the main effects of the message x personalisation interaction, $\chi^2(5) = 14.584$, $p = 0.012$, for electrodermal activity, $\chi^2(5) = 20.003$, $p = 0.001$, for early EDA, and $\chi^2(5) = 18.218$, $p = 0.003$, for late EDA. For this reason, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.813$, $\varepsilon = 0.745$, and $\varepsilon = 0.746$, respectively), electrodermal activity, $F(4.262, 83.101) = 2.962$, $p = 0.022$, early EDA, $F(4.471, 87.193) = 2.705$, $p = 0.030$, and late EDA, $F(4.473, 87.225) = 2.599$, $p = 0.036$.

Contrasts for electrodermal activity and late EDA showed an effect for affective and cognitive messages containing participant's preferred physical activity + named when compared to control messages (see Figures 7.12 and 7.13). This effect was statistically significant for participants who reported exercising less than 3 days a week, 3 days a week, and more than 3 days a week. Electrodermal activity, $F(2, 39) = 3.379$, $p = 0.044$, $\omega^2 = 0.06$, late EDA, $F(2, 39) = 3.506$, $p = 0.040$, $\omega^2 = 0.06$.

A difference in electrodermal activity reactivity can be seen for people who reported to exercise 3 days a week ($n = 11$). For people who reported to exercise less than 3 days a week ($n = 20$), electrodermal activity reactivity to messages containing the preferred physical activity and name was lower than for control messages; no difference between the type of message was found. Electrodermal activity reactivity was nearly the same for the same messages and personalisation strategies for people reporting to exercise more than 3 days a week ($n = 11$).

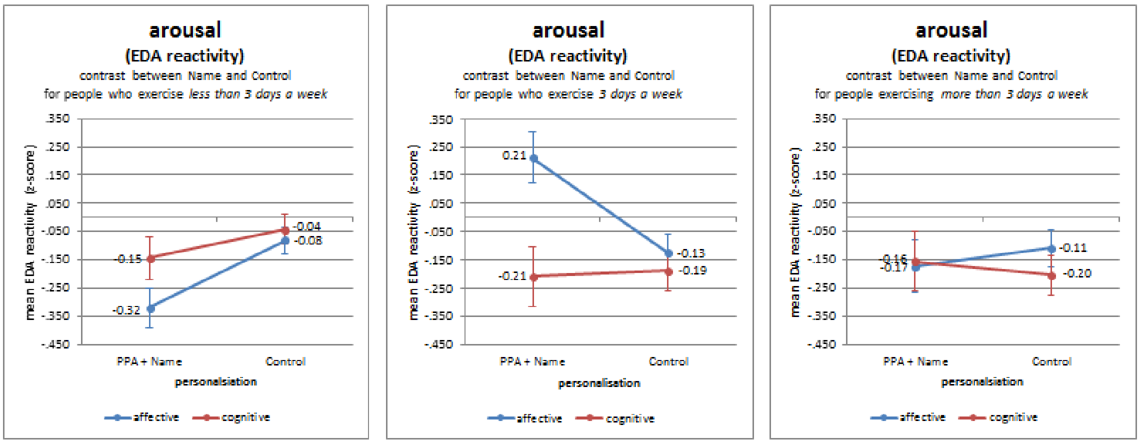

Figure 7.12 Contrasts for the message x personalisation x weekly exercising frequency interaction on electrodermal activity. For people who exercise less than 3 days a week and people who exercise 3 days a week, little difference can be observed between affective and cognitive control messages. In contrast, there is almost no difference in EDA reactivity between personalised affective and cognitive messages.

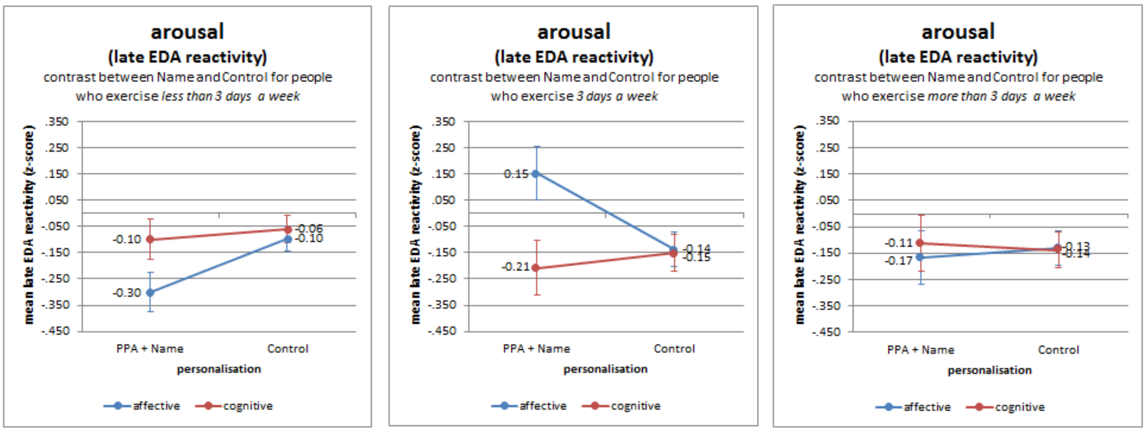

Figure 7.13 Contrasts for the message x personalisation x weekly exercising frequency interaction on late EDA. Control messages elicited a similar late EDA response for affective and cognitive control messages.

Contrasts for early EDA showed a similar effect than the previous contrasts, but for affective and cognitive messages personalised using participant's name when compared to control messages, $F(2, 39) = 3.506$, $p = 0.040$, $\omega^2 = 0.06$ (see Figure 7.14).

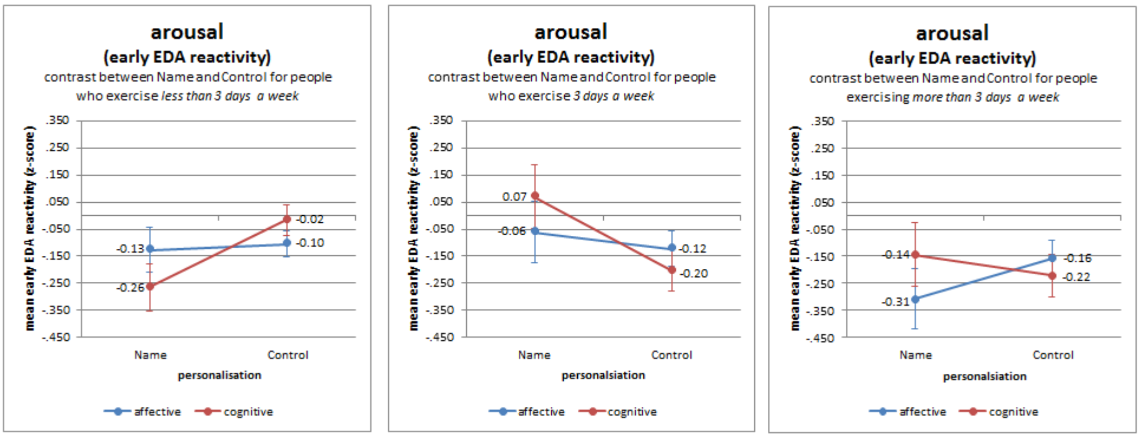

Figure 7.14 Contrasts for the message x personalisation x weekly exercising frequency interaction on early EDA showing that affective messages containing participant's name failed to elicit a strong reaction for people exercise 3 days a week or less.

The interaction message x personalisation x dieting status was found to have a significant main effect on zygomaticus major. The assumption of sphericity was violated, $\chi^2(5) = 14.584$, $p = 0.012$, and Greenhouse-Geisser estimates were used to correct the degrees of freedom ($\varepsilon = 0.813$), $F(4.878, 95.116) = 2.565$, $p = 0.033$.

Contrasts were performed to compare each dieting status with the type of message and the different personalisation strategies. These contrasts revealed a significant interaction when comparing the dieting status with the interaction type of message x personalisation, but only for messages personalised using participant's name when compared to control messages, $F(2, 39) = 9.657$, $p < 0.001$, $\omega^2 = 0.19$.

A difference between message type and personalisation can be seen for people dieting to lose weight. However, only 3 participants fell under this category (see Figure 7.15).

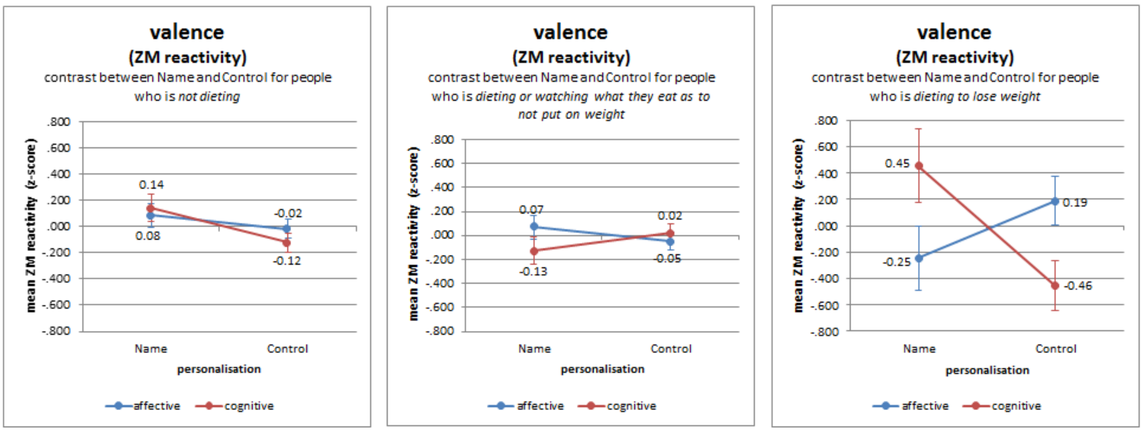

Figure 7.15 Contrasts for the message x personalisation x dieting status interaction on zygomaticus major showing that reactivities for personalised affective and cognitive messages was almost the same for people not dieting, or dieting or watching what they eat.

Self-reported arousal, valence and persuasiveness

A main effect for the interaction personalisation x exercise was found for valence, $F(3, 120) = 3.534$, $p = 0.017$. Figure 7.16 shows contrasts for the personalisation x exercise interaction. These contrasts show that messages personalised using participant's name were perceived as significantly different than control messages for participants who were already engaged in physical activity ($n = 22$), $F(1, 40) = 5.397$, $p = 0.025$, r = 0.34. Name had no effect for participants not engaged in physical activity ($n = 20$). There was no significant difference in self-reported valence for messages personalised using participant's name between those participants who reported exercising and those who reported not to exercise.

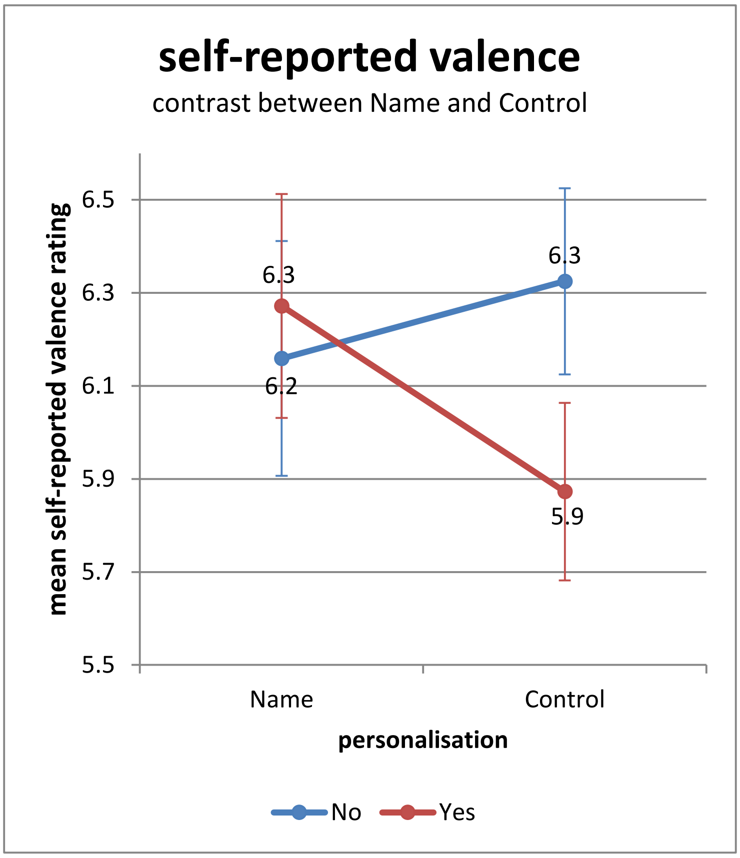

Figure 7.16 Contrasts for the personalisation x exercise engagement interaction on self-reported valence. Messages personalised using participant's name were not self-reported differently by people who reported to exercise and people who reported not to exercise.

There was a main effect for persuasiveness ratings for the interaction personalisation x exercise. Maulchy's test showed that the assumption of sphericity had been violated, $\chi^2(5) = 15.078$, $p = 0.01$, and Greenhouse-Geisser estimates were used to correct the degrees of freedom ($\varepsilon = 0.784$), $F(5.884, 1.422) = 4.139$, $p = 0.014$. Contrasts, however, did not reveal significant interactions.

Self-reported arousal showed a main effect for the interaction message x frequency, $F(2, 39) = 4.930$, $p = 0.012$, $\omega^2 = 0.02$. People who reported exercising more than 3 days a week ($n = 11$) rated cognitive messages higher for arousal than people who reported exercising less than 3 ($n = 20$) or 3 days a week ($n = 11$), see Figure 7.17.

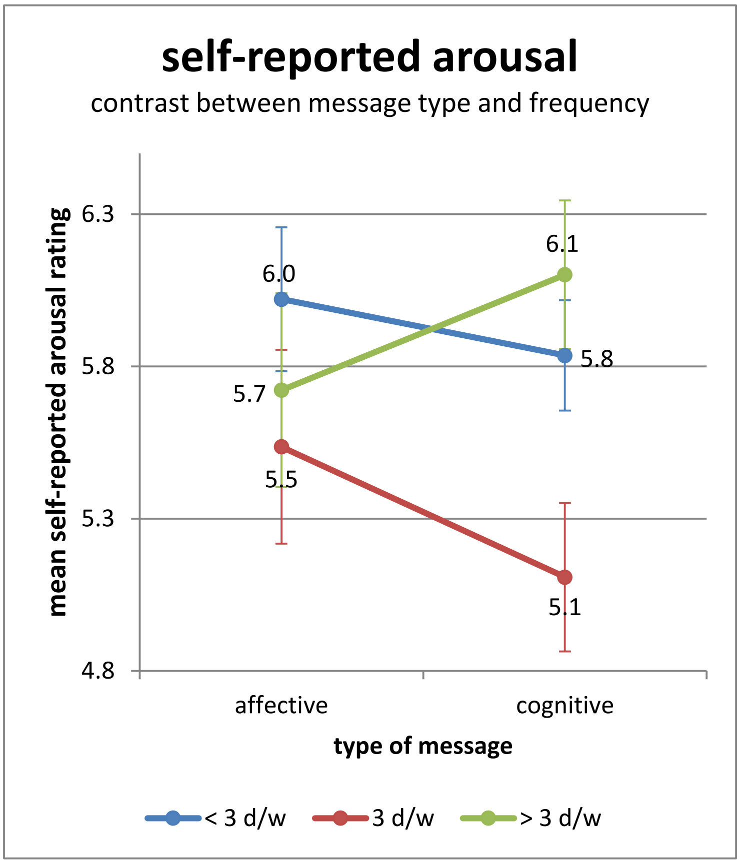

Figure 7.17 Contrasts for the message x frequency interaction on self-reported arousal. Participants who reported to exercise less than 3 days a week or three days a week self-reported affective messages as more arousing than cognitive messages.

A main effect for the interaction message x exercise frequency was also found for persuasiveness ratings $F(2, 39) = 3.988$, $p = 0.027$, $\omega^2 = 0.01$. Again, people who reported exercising more than 3 days a week ($n = 11$) rated cognitive messages as more persuasive than affective messages, as can be seen in Figure 7.18.

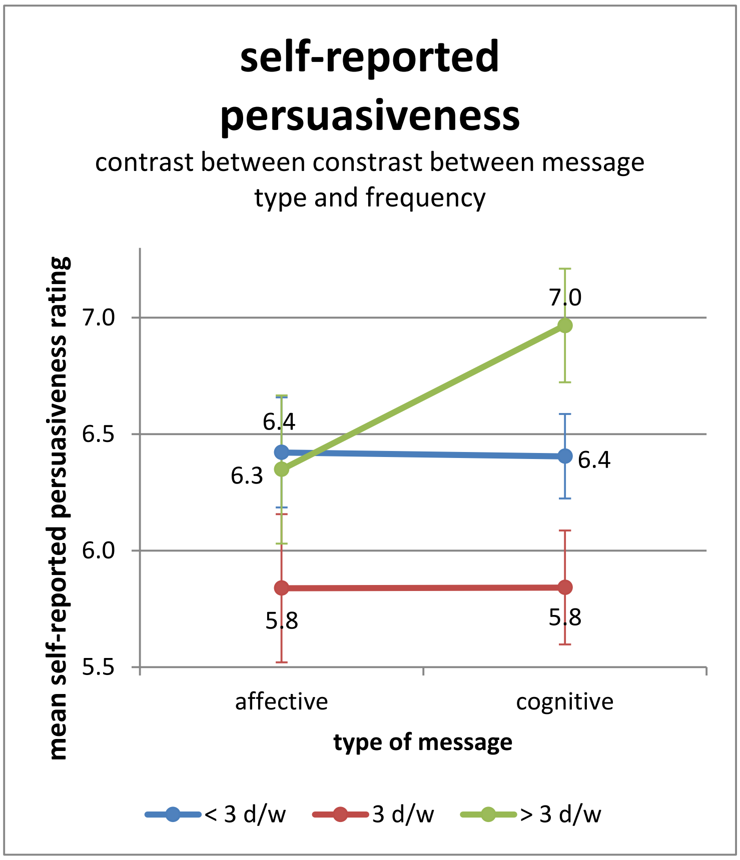

Figure 7.18 Contrasts for the message x frequency interaction on self-reported persuasion. No difference in self-reported persuasiveness was observed between affective and cognitive messages for people who reported to exercise 3 days a week or less than 3 days a week.

A main effect for self-reported valence was found for the message x dieting status interaction, $F(2, 39) = 4.005$, $p = 0.026$, $\omega^2 = 0.01$. People not dieting ($n = 20$) and people dieting or watching as to not put on weight ($n = 19$) rated cognitive messages slightly higher than affective messages. People dieting to lose weight ($n = 3$) rated affective messages higher than cognitive messages (see Figure 7.19).

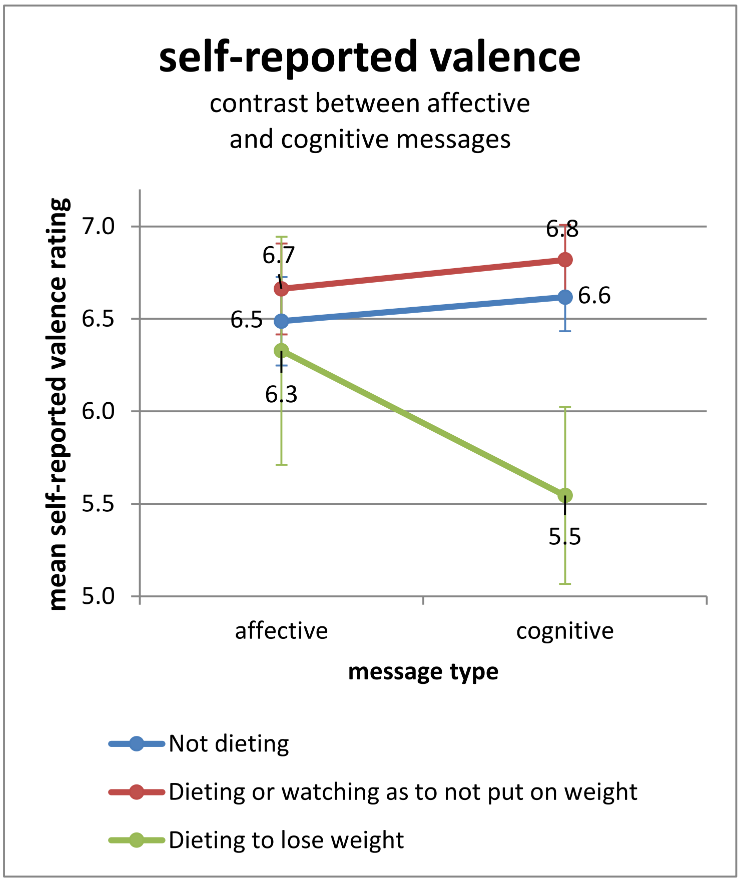

Figure 7.19 Contrasts for the message x dieting status interaction on self-reported valence. Participants who reported not to be dieting, or dieting or watching what they eat as to not put on weight self-reported valence for affective and cognitive messages very similarly.

7.6.8 Message recall

There was a main effect for the type of message recalled, $F(1, 41) = 39.093$, $p < 0.001$, r = 0.7 (see Figure 7.20).

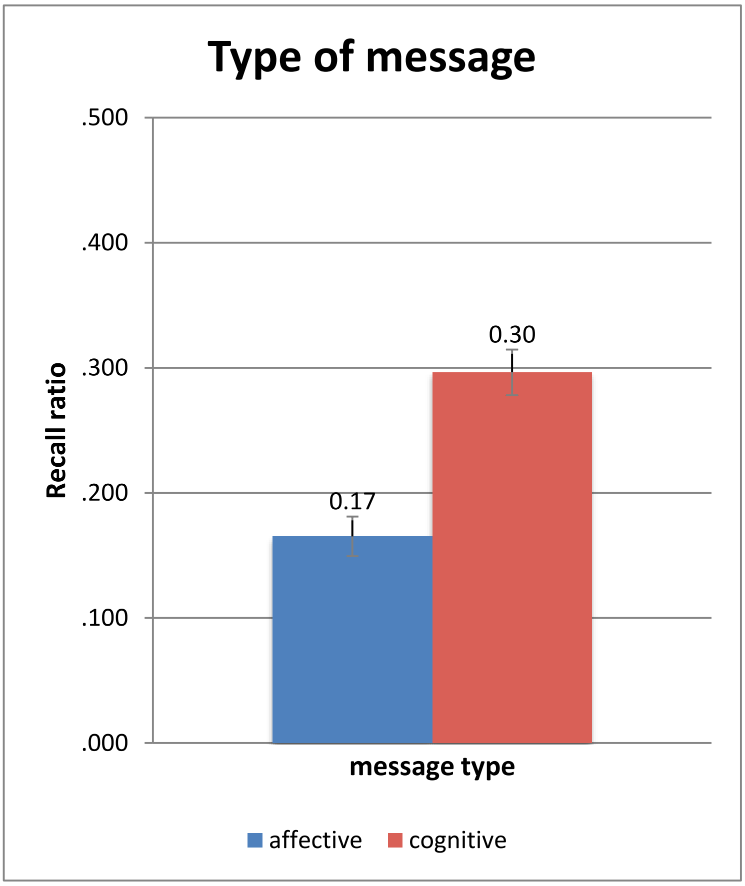

Figure 7.20 Main effect of type of message recalled, showing that cognitive messages were more recalled, almost twice.

Individual differences did not account for any other significant interactions between the type of message and/or personalisation of the messages.

7.7 Discussion

7.7.1 Arousal and valence as measured through psychophysiology and self-report

Personalising text messages did have an effect on facial electromyography, specifically on the assessment of zygomaticus major. This effect showed a moderate size effect (r = 0.3) for messages containing participant's preferred physical activity, and a large size effect (r = 0.52) was found for messages containing participant's preferred physical activity and participant's name. People perceived these types of messages more positively than untailored messages (control).

Larger effects were found for self-reported valence for the same types of message personalisation, r = 0.68 for messages containing participant's preferred physical activity, and r = 0.76 for messages containing participant's name and preferred physical activity.

Personalised messages using only participant's name failed to show effects. Other studies investigating the role of tailoring and personalisation have also failed to see effects on communication that only used participant's name. Bull et al. (1999) found in a study comparing the effects of tailored, personalised and general health messages for physical activity that people in the tailored group (e.g. participant's exercise goal, preferred physical activity) were more likely to increase their physical activity than the personalised group (e.g. messages using only participant's name) and general messages. In another study to understand the effect of printed health educational materials for weight loss, Bull et al. (2001) found that participants who received tailored materials (using information from an individual assessment) were more likely to change their behaviour.

When participants were asked to self-report arousal they rated higher personalised messages than control messages, r = 0.67 for messages including participant's preferred physical activity, and r = 0.66 for messages containing participant's name and preferred physical activity. However, measured electrodermal activity, early EDA, and late EDA did not find any effect for personalisation. Study 2 did not find any effect of electrodermal activity reactivity and self-reported arousal for these messages.

Personalising messages using participant's preferred physical activity (contextualising) and name (identification) was not enough to elicit arousal.

The findings of this study are consistent with Maslowska et al.'s (2011) results. They found that people exposed to messages that included the three personalisation characteristics (identification, raising expectations, and contextualisation) differed significantly from people exposed to generic (control) messages. Kalyanaraman & Sundar (2006) found statistical significant differences over three different levels of a web portal personalisation. Participants exposed to greater levels of content personalisation (based on participant's interest on various topics like music, sports, travel, weather, etc.) evaluated more positively the web portal than the other two groups (medium and low personalisation).

7.7.2 Self-reported persuasiveness

For this study message persuasiveness was assessed through self-reporting. Large effect sizes were found for personalised messages containing participant's preferred physical activity, and participant's preferred physical activity and name, which is consistent with the literature.

Dillard & Peck (2000) found that emotions do play an important role in persuasiveness. Their study used public service advertisements advocating different things (e.g. don't drink and drive, live an active life, never leave your child in the bathtub) and participants were asked to rate the persuasiveness of the advertisements based on either how they felt, or trying not to be biased by emotions during the judgement of the advertisements, or were given no instruction. They found that, regardless of the instruction given to participants, emotions influenced persuasiveness.

In the study described in this Chapter, messages containing participant's preferred physical activity, and preferred physical activity and name were found to be perceived as positive through facial electromyography, and through self-report measures of arousal and valence. These messages (perceived as affective) were also perceived as more persuasive than messages only containing participant's name or control messages.

The systematic review by Latimer et al. (2010) found that personalised messages resulted in significantly greater physical activity. In the study presented in this Chapter, the message x personalisation interaction found medium effect sizes for affective and cognitive messages containing participant's preferred physical activity, and participant's preferred physical activity and name. These personalised messages were rated as more persuasive compared with control messages.

7.7.3 Individual Differences

Exercise engagement and weekly exercise frequency showed some effects on electrodermal activity and late EDA. Participants who reported to exercise 3 times a week had a stronger electrodermal activity reactivity to messages containing their preferred physical activity and their name than the control messages. Early EDA, on the other hand, showed effects on messages containing participant's name when compared with control messages. Interestingly, contrasts did not reveal any effects of messages containing participant's preferred physical activity for electrodermal activity, early EDA or late EDA, which was found as a main effect. Also, contrasts for early EDA did not show the main effect found for messages containing participant's preferred physical activity and name.

These individual differences are based on participant's self-reported exercise engagement and could, therefore, be affected by recall or other biases. It may be important, to better understand these results, if participant's engagement in physical activity is a recently acquired behaviour or is it a maintenance behaviour.

Self-reported measures of valence, arousal and persuasiveness described effects for interactions of the type of message x exercise engagement or weekly physical activity frequency or dieting status. However, their size effects were very small or contrasts failed to show any significant interaction. The same happened for the personalisation x exercise engagement interaction for self-reported persuasiveness.

7.7.4 Message recall

Once again, more cognitive messages were recalled than affective messages. Personalisation of these messages failed to show a significant effect on recall. It was expected that personalised messages would be remembered more easily than impersonal messages; however, this did not happen.

7.7.5 Limitations

This study had several limitations. First, the effects of personalisation were observed over electrodermal activity reactivity and facial electromyography reactivity, self-reported arousal, valence and persuasiveness, and message recall, but not on physical activity. Unlike study 2 (Chapter 6), there is no direct evidence that personalisation of the messages used in this study would have had an effect on behaviour. However, there is some evidence that personalisation has an effect on physical activity. Kim & Glanz (2013) used personalised motivational messages to increase step count in older African-Americans with positive results. In the study of Prestwich et al. (2009) a significant increase in exercise frequency was found for participants receiving text message reminders than those who did not. Participants wrote their own text message content so that message content was relevant to them. In an intervention to promote brisk walking, Prestwich et al. (2010) found text messages reminding people of their brisk walking goal or plan to be effective.

A second limitation is that participants were not recruited based on their engagement in physical activity or plan to engage in physical activity. Twenty-seven participants reported to regularly engage in physical activity. However, 5 of these failed to meet the criteria of exercising at least 3 times a week for a minimum of 30 minutes.

Third, the number of messages was limited by the original library developed by Sirriyeh et al. (2010), which did not allow this study to have a balanced number of manipulations. For each type of message (affective or cognitive) each manipulation consisted of only 3 personalised messages, leaving 5 messages as control for each condition (10 control messages in total). A larger number of messages allowing a balanced number of manipulations might have shown larger effects.

Results from the individual differences analyses need to be further investigated to fully understand the effect of individual differences on personalisation through trials. mHealth research on using text messages to deliver interventions aimed to increase physical activity is still in its infancy and there is still a lot to understand. Theory and evidence about personalisation, although substantial, has been more widely researched for written communication (e.g. newsletters), or dynamic media (e.g. websites and PSAs). Little is known of its effect on text messages, which is constrained to 160 characters, and specifically for text messages promoting healthy behaviours.

7.8 Chapter Summary

The effect of personalisation on arousal and valence using psychophysiology measures and self-report was explored, as well as its effect on self-reported persuasiveness. It was found that personalised messages using contextualisation and contextualisation + identification as personalisation strategies were effective. Medium effect sizes were observed for valence on zygomaticus major. Large effect sizes were observed for self-reported measures of arousal, valence and persuasiveness when compared to control messages. These methods were successful at finding differences between some levels of message personalisation.

Analyses of individual differences revealed medium effect sizes for measured arousal, and medium to small effect sizes for self-reported measures. Findings of this study are consistent with the literature, giving useful insights into how personalisation affects people and its effect over persuasiveness. Personalisation strategies of contextualisation and contextualisation + identification are suggested as the most effective strategies for promoting healthy behaviours.

Chapter 8:

General discussion

Chapter 8: General discussion

8.1 Overview

Digital interventions for health behaviour change have been the focus of much eHealth and mHealth research in fields such as psychology, public health, health promotion, health communication and computer science, among many others. Text messaging interventions have been demonstrated to be effective for changing a range of health related behaviours such as smoking, binge drinking, diet, physical inactivity and safer sex/condom use (Free et al., 2013; Head et al., 2013; Militello et al., 2012). Using mobile devices to support medicine, nursing and public health has great potential but it also presents great challenges, as technology is rapidly and constantly changing.

Text messaging interventions provide a fast, inexpensive and interactive medium to reach people almost anywhere and at any time, and could potentially help tackle important global health problems, such as the current obesity crisis. SMS interventions have a number of characteristics that could moderate intervention effectiveness (e.g. directionality or intervention duration). This thesis has presented a systematic review, meta-analysis and meta-regression summarising the evidence on SMS interventions for weight loss and physical activity, evaluating the contribution of the different intervention characteristics to intervention effectiveness.

Although message content is not the only characteristic in SMS interventions that may contribute to its effectiveness, it is often seen as the central driver for behaviour change (Ybarra, Holtrop, Bağci Bosi, & Emri, 2012). It has been reported that health messages reaching people at an emotional level (Kiviniemi et al., 2007; Morris et al., 2015; Sirriyeh et al., 2010) and that are personalised (Neuhauser & Kreps, 2003), are more effective.

This thesis examined whether psychophysiology methods could be used to explore the influence that affective messages and personalisation have on people, and to test and improve messages before a trial.

Three empirical studies using psychophysiology measures as a method to assess the affective qualities of text messages (arousal and valence) were described. In addition to psychophysiology, self-reported measures of arousal and valence, and recall were used to explore message impact.

8.2 Summary of findings

The aim of this thesis was to understand people's response to affective text messages and personalisation using psychophysiological methods. This thesis had four objectives (see Chapter 2, section 2.2) which were approached through a systematic review, meta-analysis and meta-regression, and three empirical studies.

8.2.1 Systematic review (Chapter 3)

The first objective of this thesis was to determine the effectiveness of SMS interventions and to evaluate the contribution of different intervention characteristics. This review included a total of 21 studies using SMS text messages as their main communication/delivery method. Interventions designed for weight loss, weight maintenance and for promoting physical activity were included.

The meta-analysis found a favourable effect for SMS-based interventions (g = 0.18 [0.06, 0.31], p <0.01), which was consistent with recent systematic reviews exploring different health applications (Cole-Lewis & Kershaw, 2010; Free et al., 2013; Hall et al., 2015; Head et al., 2013).

The meta-regression for intervention duration showed that intervention effectiveness decays with time. Behaviour change research has mostly focused on short-term changes. In the case of digital interventions, observed short-term effects could be the product of a novelty effect.

Several intervention characteristics were evaluated through subgroup analyses. Surprisingly, the analysis of interventions that incorporated personalised messages did not show them to be more effective than impersonal messages. Systematic reviews of interventions for other behavioural outcomes have shown an effect for personalisation on intervention effectiveness (Bull et al., 2001; Head et al., 2013; Jensen et al., 2012; Noar et al., 2007). Intervention duration could explain why no effect was found for personalisation in this review. The average duration of interventions for weight management reporting the use of personalised messages was only 12 weeks.

Evidence on how text messages are developed for these types of interventions and how they are tested is limited and rarely reported. Only 8 interventions included in this review reported how the messages were created (Fassnacht et al., 2015; Huang et al., 2014; Nguyen et al., 2013; Patrick et al., 2009; Prestwich et al., 2009; Prestwich et al., 2010; Shaw & Bosworth, 2012; Sirriyeh et al., 2010). Intervention characteristics that were not explored and constitute future research opportunities to deepen our understanding about how these interventions work include: using self-reported vs objective measures, the effect of receiving repeated messages, communication initiator and the number and type of behaviours targeted in the intervention (e.g. self-monitoring).

There is limited evidence at the moment to understand how these characteristics and, possibly, their combination, contribute to intervention effectiveness. New message-based media are starting to be used to deliver these interventions. For example, a recent study used WhatsApp to deliver a physical activity intervention in older adults (Muntaner-Mas et al. 2015). Twitter has also been used to deliver a weight-loss intervention with promising results (Pagoto et al., 2015). Such interventions potentially share the same intervention characteristics as SMS-based interventions. Future reviews should consider including these types of interventions.

8.2.2 Study 1 (Chapter 5)

Neuromarketing methods provide an objective means to understand people’s response to affective messages and personalisation. This concept was developed in 1990 by Harvard psychologists and later coined by Smidts (2002), who defined it as a set of methods to better understand consumers and their reactions to marketing stimuli by measuring biosignals.

Psychophysiology measures had been suggested as a way to distinguish positive and negative affect to identify emotional shifts in health communication by Nabi (2014). Facial electromyography has been associated with emotional valence (Larsen et al., 2003), and electrodermal activity with arousal (Dawson et al., 2007).

The second objective of this thesis was to examine facial electromyography and electrodermal activity as methods to objectively measure affective valence and arousal, respectively. Words of varying levels of self-reported valence and arousal taken from a validated list (ANEW) were used for this purpose.

This study found that corrugator supercilii reactivity was negatively associated with valence and electrodermal activity reactivity was positively associated with arousal. Stronger associations had been found by other studies using pictures (Codispoti et al., 2001) and sounds (Bradley & Lang, 2000; Larsen et al., 2003). These associations confirm that facial electromyography and electrodermal activity are sensitive methods to measure valence and arousal, and can potentially differentiate affective messages from general or cognitive messages.

Additionally, this study tested five of the most frequently used words in physical activity SMS intervention messages and the participant's name. The participant's name elicited the strongest electrodermal response, even stronger than the most arousing words being tested (*explosion* and *killer*). This strong response suggested that using participant's name to personalise text messages promoting healthier behaviours is an effective strategy to capture people's attention. It also suggests that name-based personalisation (identification) of messages could lead to a greater intervention efficacy, as proposed by Head et al.'s (2013) in their systematic review and other studies, like Dijkstra's (2005) on smoking cessation.

8.2.3 Study 2 (Chapter 6)

Study 2 explored affective and cognitive messages promoting physical activity using psychophysiology, self-reported measures and recall, as methods to understand the impact of the messages on people.

Study 1 demonstrated strong associations between facial electromyography reactivity over corrugator supercilii and valence, and electrodermal activity response and arousal. Affective messages have been found to be more effective in making people more physically active (Sirriyeh et al., 2010). It was therefore hypothesized that affective messages would be perceived as more positive and arousing than cognitive messages.

Contrary to expectation, no differences in electrodermal activity reactivity and facial electromyography reactivity were observed between the types of messages. Self-reported measures were also unable to differentiate between affective and cognitive messages. This suggests that participants perceived both types of messages as equally affective in terms of arousal and valence.

Affective and cognitive messages did not differ greatly in their structure. All messages told participants that physical activity can lead to either an emotional (e.g. feeling cheerful) or a health benefit (e.g. promote stronger muscles). Words used in the affective messages (e.g. *happier* or *excited*) are not perceived by people as arousing, according to the self-reported value for arousal from the ANEW list; however, they are perceived as positive. This could explain the absence of affective physiological responses (arousal) to these messages.

It was also hypothesised that affective messages would be more easily recalled than cognitive messages, as research has shown that arousal and valence play an important role on recall and memory (Gomes et al., 2012; Newell et al., 2001; Sharot & Phelps, 2004). Unexpectedly, participants recalled more cognitive messages than affective messages. This could be explained by participant's current engagement in physical activity. Most participants reported to be already engaged in physical activity and they may have been more interested in the long-term gains of physical activity than its affective gains.

8.2.4 Study 3 (Chapter 7)

The aim of study 3 was to explore the effect of personalisation on the impact of affective and cognitive messages using psychophysiological measures. The same messages used in Study 2 were personalised for each participant using their name, their preferred physical activity, and both their name and preferred physical activity. Control messages did not include their name or their preferred physical activity. On the contrary, these messages used physical activities that participants had already indicated to be unlikely to appeal to them.

Personalisation was found to have an effect on zygomaticus major reactivity. The same was found for self-reported arousal and valence for messages containing participant’s preferred physical activity, and participant’s name and preferred physical activity. These responses are consistent with the literature studying personalisation (Bull et al., 2001; Kalyanaraman & Sundar, 2006; Maslowska, Smit, & van den Putte, 2010; Maslowska, 2013).

Electrodermal activity reactivity, however, showed no difference between the types of personalisation, even when messages included participant’s name. Study 1 showed that participant’s name elicited the strongest electrodermal activity reactivity. This effect was not observed in Study 3 for any of the messages containing only participant’s name. It is important to recognise that a message does not immediately elicit arousal or is perceived as positive or negative. Rather, the emotional response develops over time (Bolls et al., 2001). It is possible that the rest of the message in which participant’s name was used did not add or maintain the level of arousal, explaining why no electrodermal activity reactivity was observed.

Maslowska et al. (2010) examined the effectiveness of personalisation of digital messages advertising a University sports centre and found that personalisation strategies of identification, raising expectations and contextualisation did not differ significantly from general messages when used on their own. However, they found that the combination of the three strategies in a message was perceived as significantly different from a general message. This could explain why there was no effect for messages containing only participant’s name. However, Study 3 did find a significant difference for messages containing participant’s preferred physical and control messages.

The systematic review (Chapter 3) revealed that little is known on how intervention text messages are developed. Thus, special attention needs to be paid to the content of the messages, hence the focus of this research on message content and personalisation.

The empirical work in this thesis explored psychophysiology as a potential technique to better understand people's response to affective text messages and personalisation. Overall, no difference was found in Study 2 between affective and cognitive messages, which were based on previously validated messages by Sirriyeh et al. (2010). On the other hand, Study 3 demonstrated the effect of personalisation using participant's preferred physical activity, and participant's name and preferred physical activity using psychophysiological and self-reported measures.

The measures obtained through psychophysiological assessment and self-report appeared to be similar in their capacity to determine differences between personalised and impersonal messages. Both measures found the same when comparing affective and cognitive messages only (Study 2). However, it was during the individual differences analyses where it was found that people rated messages differently for arousal depending on their engagement in physical activity.

In Study 3, while self-reported arousal found significant differences for personalised messages, electrodermal activity reactivity did not find this. Only when individual characteristics (e.g. exercise engagement) were included in the analysis as a between-subject factor did psychophysiology measures find differences between the messages.

8.3 Research implications

The empirical study on personalisation (Chapter 7) presented in this thesis demonstrated that messages personalised using identification and contextualisation can elicit a distinctive physiological response. Self-reported measures of valence and arousal found that these messages have an effect on people for these two dimensions of emotion. Messages that were personalised only using participant's name (identification) did not elicit a response nor show an effect in self-reported measures of arousal and valence.

Most of the interventions included in the systematic review (Chapter 3) that tailored text messages (Bouhaidar et al., 2013; Faghanipour, Hajikazemi, Nikpour, Shariatpanahi, & Hosseini, 2013; Haapala et al., 2009; Huang et al., 2014; Nguyen et al., 2012; Nguyen, Gill, Wolpin, Steele, & Benditt, 2009; Patrick et al., 2009; Shapiro et al., 2012) used feedback as a way of tailoring interventions to participants. These interventions used a predefined library of text messages to fit participant's behaviour and/or used participant's name to personalise them. The research presented in this thesis found that using only participant's name is not enough to elicit a physiological response or for the messages to be perceived as arousing. Other studies have also reported that only using people's name to personalise messages is not enough to make them effective or persuasive (Maslowska et al., 2010, 2011). Only Prestwich et al. (2009, 2010) have asked participants to create their own messages, which allowed messages to be specific to the participant's context (e.g. specific plans related to achieving a physical activity goal).

It is therefore suggested that future text messaging interventions use not only participant's name to personalise messages, but also use contextualisation (e.g. participant's preferred physical activity or other personal information) to make messages more personal, relevant and affective. An example of this would be a message such as: "Hi John! Remember that swimming makes you feel happy."

Psychophysiology assesses subconscious processes that cannot be accessed by other measures and captures more sensitive data (Tomarken, 1995) that can inform the development of text messages for behaviour change interventions. Psychophysiology and self-reported measures of arousal and valence do seem to effectively discriminate messages when looking into participant's individual characteristics. Both measures give useful insights on different levels of consciousness. Psychophysiology gives insights of the subconscious and self-report gives insights of conscious affective impact. When possible, it is recommended to use psychophysiology and self-reported measures concurrently to better understand how messages are perceived by people and how they respond.

Recently, wearable devices measuring electrodermal activity (iCalm) or heart rate (HRM watches) have been made commercially available. These devices, although they do measure what they claim, need to be used with caution for research purposes of this kind. External factors have an influence on measures of skin conductivity and heart rate that magnify the signal and this could be recognised as a false positive. Electrodermal activity and heart rate variability are techniques with limitations (see Chapter 1, section 1.4.1) that can be somehow controlled in a laboratory environment, like room temperature and humidity. These important factors cannot be controlled outside a laboratory environment. Limitations to heart rate monitors include dehydration and ambient temperature (Achten & Jeukendrup, 2003), but also sensor activity and device placement (Parak & Korhonen, 2014).

The empirical studies presented in this thesis recorded physiological responses to the messages in an isolated environment with controlled conditions, which are not a true representation of how an SMS intervention works or how a message is received. All external factors were controlled as much as possible in the laboratory. In the experimental studies, messages were presented one after the other in a single session. In reality, an SMS-intervention will deliver messages with a certain frequency (e.g. one every day). Immediate reactions to the messages were obtained in the laboratory, but it is still unclear how these messages will be perceived under 'normal' intervention conditions and what their effect would be over the targeted behaviour.

Message content is just one intervention characteristic, but more evidence is needed to understand which characteristics of SMS interventions contribute to intervention effectiveness. The methods used in this research were not used to predict behaviour uptake and engagement, but only message affect. Randomised controlled trials are still needed to better understand the effect of personalisation and other intervention characteristics on behaviour uptake.

The findings described in this thesis may be transferable to other behaviours and other media. This research used physical activity and SMS as a case study, but the same type of experiments could have been used for understanding people's response to affective messages and personalisation for other behaviours, like smoking, binge drinking or sexual health.

The use of SMS messages in the UK has declined in the past years being substituted by other instant messaging apps, such as WhatsApp, and other communication platforms like Hangouts or Twitter. However, text messaging is still a popular and cost effective way of communication, especially in low and middle-income countries. The same intervention characteristics present in SMS interventions can be found in interventions using other text messaging media, like directionality, personalisation and frequency.

8.4 Research limitations

Specific limitations of each empirical study have been described in the corresponding chapters. However, there are some limitations that are important to highlight here. Firstly, the evaluation of the text messages and personalisation was done in a controlled environment measuring participant's physiological and self-reported responses.

This research did not measure changes over the targeted behaviour (physical activity). Psychophysiology and self-reported measures are only an indication of people's response to the messages (personalised and not personalised), not an indication of actual behaviour engagement or willingness to engage after receiving/reading these messages.

The text messages evaluated in this thesis were taken from a study that demonstrated the effectiveness of affective messages over cognitive messages to promote physical activity. However, this intervention was only evaluated for 2-weeks and its long-term effects are unknown.

This research aimed to understand people's response to affective text messages and personalisation using psychophysiological methods. Because the main research interest was in the methods, participants were not recruited based on their current engagement in physical activity. No difference was found for self-reported and physiological responses between affective and cognitive messages. This could be explained by the participant's engagement in physical activity. In the study by Sirriyeh et al. (2010), from which the messages were taken for this research, it was found in a post-hoc analysis that there was no difference in effectiveness between affective and cognitive messages for people already engaged in physical activity. People already engaged in physical activity may be more interested in long term benefits. Short-term benefits may be more attractive for people not engaged in regular physical activity or for those who are thinking of engaging in regular physical activity; affective messages could facilitate behaviour change in these groups. Recruitment could be seen as a limitation, but other studies exploring the effect of affective and cognitive messages over physical activity have recruited participants regardless of their engagement in physical activity (Morris et al., 2015; Sirriyeh et al., 2010).

Psychophysiological measures have their own limitations. Electrodermal activity is susceptible to external factors, like temperature and humidity, which for these studies were controlled as much as possible. Internal factors, like current concerns, have been found to have an effect on skin conductivity (Nikula et al., 1993). Internal factors are much more difficult to control and could have had an influence on arousal when measured through electrodermal activity. Electrodes used for facial electromyography may alter the natural facial expression. A long baseline recording (5 minutes) and other tasks (e.g. rating messages) were included to minimise this effect by trying to make participants unaware of the electrodes and to focus them on the task.

Despite all these limitations, special care was taken to follow a methodological approach following the appropriate guidelines and publication recommendations for measuring and processing physiological responses (Boucsein et al., 2012; Fridlund & Cacioppo, 1986). Also, this research not only used psychophysiological measures to understand valence and arousal, but also a validated instrument developed by Bradley & Lang (1994) - MANIKIN - for measuring affect (arousal and valence).

8.5 Future directions

To better understand the real influence that affective messages and personalisation have on behaviour it is crucial to objectively measure it. A limited number of studies have tested this for physical activity (Morris et al., 2015; Sirriyeh et al., 2010) but using only self-reported measures of exercise. Evidence from the empirical studies presented in this thesis suggests that certain personalisation strategies could be more effective at changing people’s behaviour than impersonal messages. Napolitano &

Marcus (2002) have reported that personalisation is associated with greater intervention effectiveness for information on physical activity using printed materials and information technologies. Head et al. (2013) also reported the effectiveness of using personalisation and tailoring strategies for text messaging interventions. Future research should evaluate personalisation strategies on actual behaviour (in this case physical activity) through a trial to help understand the role of personalisation in intervention effectiveness.

In the meta-regression presented in Chapter 3, longer intervention duration was found to lead to a decline in intervention effectiveness. This needs to be further explored to understand how to extend intervention effectiveness. Using personalised affective messages may help sustain effects of behaviour change interventions a little longer. Other intervention characteristics, like directionality and receiving feedback, may also extend intervention effectiveness.

Little is known about digital intervention engagement and research is currently addressing this issue (Alkhaldi et al., 2015). Understanding what engages people in a digital intervention may also shed some light into extending intervention effectiveness. One way of doing this would be applying principles of gamification to behaviour change interventions, as suggested by Cugelman (2013), to increase engagement and, possibly, lead to sustained behaviour change. Some of these principles (e.g. providing feedback on performance) have already been applied to SMS-based interventions for physical activity (Nguyen et al., 2009) but could be further explored using, for example, a mobile phone app to track daily step count and giving feedback on daily performance.

People's shift from SMS text messaging to other communication media (Deloitte, 2014), like WhatsApp and Hangouts, has opened up different messaging channels and capabilities. The incorporation of pictures and video in these media could provide a useful way of engaging and communicating with people more interactively. Larsen et al. (2003) showed that pictures are strongly associated with valence while words presumably elicit milder effects. The use of emoticons in text messages may enhance the affective component of messages. Some research on the effect of emoticons over user preferences in behavioural interventions has been done (Muench, van Stolk-Cooke, Morgenstern, Kuerbis, & Markle, 2014).

8.6 Conclusion

The world obesity crisis and the rapid development of mobile technologies have motivated the interest of researchers to find new ways to tackle this growing problem. The development of mHealth interventions has been supported by the WHO. SMS-based digital interventions for physical activity have been explored for the past 12 years.

The systematic review, meta-analysis and meta-regression presented in Chapter 3 found that SMS interventions are an effective way to promote physical activity and weight loss. However, it found that most of the intervention characteristics analysed (e.g. tailoring) do not contribute to intervention effectiveness. The main finding came from the meta-regression on intervention duration, showing that intervention effectiveness deteriorates with time. This research adds to our understanding of the effectiveness of SMS interventions for weight loss and physical activity, and which intervention characteristics contribute to intervention effectiveness.

There is limited knowledge on how text messages are developed for weight and physical activity SMS interventions. It has been suggested that affective messages should lead to intervention effectiveness. This has been demonstrated to be true for other health behaviours (Becheur & Valette-Florence, 2014; Dunlop et al., 2008). Recent studies have explored the effect of affective messages on physical activity (Morris et al., 2015; Sirriyeh et al., 2010); they have found that affective messages lead to an increase in physical activity. Psychophysiology was used as a method to objectively measure emotional valence and arousal to measure subconscious responses to message arousal and valence. Other measures of affect used in this research were self-report and recall.

Findings from this research measuring valence and arousal of affective and cognitive messages failed to identify differences between these two types of messages using psychophysiology measures and self-report. However, cognitive messages were more easily recalled than affective messages. As

80% of the sample reported to regularly engage in physical activity, this could explain why cognitive messages were more easily recalled.

Personalisation has been studied for some time and by different academic groups (e.g. marketing). Personalisation strategies of identification and contextualisation were explored in this thesis as a means to enhance the affective response to text messages. This research adds to our knowledge on the impact of personalisation of affective and cognitive messages for physical activity. It also revealed people’s perception of personalised communication as an effective mean to persuade them to engage in physical activity.

Personalisation through identification and contextualisation is suggested to be the most effective way to increase message impact and persuasion, as measured through psychophysiology and self-report. Identification alone was found to be insufficient to elicit a statistically significant physiological response measured through facial electromyography, electrodermal activity or when measured through self-report.

Overall, this research contributes to our knowledge about the development of more effective health promotion SMS text messages using psychophysiological methods, self-report and recall to understand people’s response to affective text messages and personalisation. The different levels of consciousness measured by these methods is a useful addition to other methods informing the development of future SMS interventions for physical activity and, potentially, other health behaviours.

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Appendices

Appendix A1 – Characteristics of included studies

Bouhaidar (2013)

Methods	Quasi-experimental
Participants	28 participants; Overweight and obese adults (18-yo and older, M=46.6 yo, intervention group, M=42.5 yo control group); United States of America
Interventions	12-weeks study; INTERVENTION: 2 SMS per week, CONTROL: no SMS; Library development not reported; Tailored SMS; No feedback provided; Bidirectional communication; Health Promotion Model
Outcomes	Weight loss
Notes	Drop out: 1/14 (7.14%) intervention, 1/14 (7.14%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Participants were not randomised but were selected depending on their meeting location to preserve group cohesiveness.
Allocation concealment (selection bias)	Unclear risk	Not enough information to assess this outcome.
Blinding of participants and personnel (performance bias)	Unclear risk	Not enough information to assess this outcome.
Blinding of outcome assessment (detection bias)	High risk	Participants and researchers were not blinded to body weight.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.

Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

de Niet (2012)

Methods	Randomised Controlled Trial
Participants	141 participants; Overweight and obese children (7-12 yo); Netherlands
Interventions	36 weeks (9 months); INTERVENTION: 1 SMS per week, CONTROL: no SMS; Library development not reported; Use of tailoring not reported; Feedback provided; Bidirectional communication; Self-monitoring
Outcomes	BMI-SDS
Notes	Drop out: 12/73(16.44%) intervention, 21/68 (30.88%) control

Risk of bias table

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Randomisation allocation was printed on paper in a sealed envelope.
Allocation concealment (selection bias)	Low risk	Researcher randomised children to SMSMT or control group by picking an envelope from a basket.
Blinding of participants and personnel (performance bias)	Low risk	No performance bias identified
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.

Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Faghanipour (2013)

Methods	Quasi-experimental
Participants	80 participants; Overweight and obese women (M=37.1 yo intervention group, M=38 yo control group); Iran
Interventions	2 weeks; INTERVENTION: 15 SMS per week, CONTROL: no SMS; Library development not reported; Tailored messages; Feedback provided; Bidirectional communication; Self-monitoring
Outcomes	Weight
Notes	Drop out: 3/40 (7.5%) intervention, 4/40 (10%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	For avoiding contamination, participants were selected from two separate administrative departments. Those departments were randomly assigned to either control or experimental group.
Allocation concealment (selection bias)	Low risk	No selection bias identified.
Blinding of participants and	Low risk	Subjects in both experimental and control groups were not informed of their group

personnel (performance bias)		allocation status and were blinded to the group's assignment.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Unclear risk	The control group was not instructed to weekly self-weigh during the study.

Fassnacht (2015)

Methods	Pilot
Participants	49 participants; Children (8-10yo); Portugal
Interventions	8 weeks; INTERVENTION: 7 SMS per week, CONTROL: No SMS; Library was translated into Portuguese from Shapiro et al.'s (2008) study, original article did not report how the library was developed; Untailored communication; Feedback provided; Bidirectional communication; Self-monitoring
Outcomes	Physical activity (in minutes)
Notes	Drop out: none

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	By tossing a coin, the children of 2 school classes were assigned to either a monitor or control condition.

Allocation concealment (selection bias)	Low risk	No selection bias identified.
Blinding of participants and personnel (performance bias)	Low risk	No performance bias identified.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Unclear risk	The study talks about using pedometers to measure step count, however it reports exercise minutes.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Haapala (2009)

Methods	Randomised Controlled Trial
Participants	125 participants; Overweight and obese adults (25-44 yo); Finland
Interventions	52 weeks (1-year); INTERVENTION: 7 SMS per week, CONTROL: No SMS; Library development not reported; Tailored communication; Feedback provision; Bidirectional communication; Self-efficacy
Outcomes	Weight
Notes	Drop out: 17/62 (24.42%) intervention, 23/63 (36.51%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Allocation concealment (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of participants and personnel (performance bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of outcome assessment (detection bias)	Low risk	Study nurse blinded to randomization procedure.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Unclear risk	The control group received no intervention but was offered the weight-loss intervention free of charge after the 12-month visit. Unclear if they knew they were in the control group at the time of allocation.

Helsel & Jakicic (2009)

Methods	Randomised Controlled Trial
Participants	30 participants; Overweight and obese adults (M=44.2 yo); United States of America
Interventions	16 weeks; INTERVENTION: 21 SMS per week, CONTROL: No SMS; Library development not reported; Untailored communication; No feedback provision;

	Unidirectional communication; Self-monitoring
Outcomes	Weight
Notes	Drop out: 7% intervention, 46% control

Risk of bias table

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Allocation concealment (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of participants and personnel (performance bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of outcome assessment (detection bias)	Unclear risk	Insufficient information to assess this outcome.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Huang (2014)

Methods	Randomised Controlled Trial
Participants	38 participants; Children that survived acute lymphoblastic leukaemia with normal Weight (8-18 yo); United States of America
Interventions	16 weeks; INTERVENTION: web -and-text (14 SMS per week) and phone counselling, CONTROL: printed material, general health tips and biweekly call from health coach in month 1 and monthly in months 2-4; Library developed through focus groups with patients and care teams; Tailored communication;

	No feedback provision; Bidirectional communication; Social cognitive theory
Outcomes	Weight
Notes	Drop out: 1/19 (5.26%) intervention, 2/19 (10.53%) control

Risk of bias table

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not enough information to assess this
Allocation concealment (selection bias)	High risk	Equal randomization was stratified by age
Blinding of participants and personnel (performance bias)	High risk	Subjects were not blinded to group assignment
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Kim & Glanz (2013)

Methods	Randomised Controlled Trial
Participants	39 participants; African-American adults (60-85 yo); United States of America
Interventions	6 weeks; INTERVENTION: 3 SMS per week, CONTROL: no SMS; Library development not reported; Untailored communication; No feedback provision; Unidirectional communication; General encouragement

Outcomes	Step count
Notes	Drop out: 1/26 (3.7%) intervention, 2/12 (16.67%)

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were assigned randomly to a control or intervention group by a flip of the coin.
Allocation concealment (selection bias)	Low risk	No selection bias identified.
Blinding of participants and personnel (performance bias)	High risk	Participants were not blinded to the allocation of intervention.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Newton (2009)

Methods	Randomised Controlled Trial
Participants	78 participants; Diabetic adolescents (11-18 yo); New Zealand
Interventions	12 weeks; INTERVENTION: 1SMS weekly, CONTROL: No SMS; Library development not reported; Use of tailored communication not reported; No feedback provision; Unidirectional communication; General encouragement

Outcomes	Step count
Notes	Drop out: 3/38 (7.89%) intervention, 1/40 (2.5%) control.

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to assess this outcome
Allocation concealment (selection bias)	Unclear risk	Insufficient information to assess this outcome
Blinding of participants and personnel (performance bias)	Unclear risk	Insufficient information to assess this outcome
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Nguyen (2009)

Methods	Pilot
Participants	17 participants; Stable COPD adults (>=40 yo); United States of America
Interventions	24 weeks; INTERVENTION: 7 SMS per week, CONTROL: no SMS; Library development not reported; Tailored communication; Feedback provision; Bidirectional communication; Self-efficacy
Outcomes	Step count
Notes	Drop out: none

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Allocation concealment (selection bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of participants and personnel (performance bias)	Low risk	No performance bias identified.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Nguyen (2012)

Methods	Randomised Controlled Trial
Participants	151 participants; Overweight and obese adolescents (13-16 yo); Australia
Interventions	104 weeks (2 years); INTERVENTION: 0.5 SMS per week, CONTROL: no SMS; Library developed by experts; Tailored communication; Feedback provision; Bidirectional communication; Cognitive behavioural approach
Outcomes	Weight
Notes	Drop out: 6/73 (8.22%) intervention, 4/78 (5.13%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated randomization sequence stratified by sex, age group, and intervention site.
Allocation concealment (selection bias)	Low risk	Allocation concealed in sequentially numbered opaque envelops prepared by the trial manager.
Blinding of participants and personnel (performance bias)	Low risk	No performance bias identified.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Patrick (2009)

Methods	Randomised Controlled Trial
Participants	78 participants; Overweight or obese adults (25 - 55 yo); United States of America
Interventions	16 weeks (4 months): INTERVENTION: 14-35 SMS/MMS per week, printed material, monthly phone calls from health counsellor, CONTROL: monthly printed material; Library developed through focus groups; Tailored communication; Feedback provision; Bidirectional communication; Self-efficacy

Outcomes	Weight loss
Notes	Drop out: 6/39 (15.38%) intervention, 7/39 (17.95%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Individuals were assigned to either comparison or intervention group by a computer-generated process using simple randomisation
Allocation concealment (selection bias)	Low risk	Participants were not informed of their group allocation status during this process
Blinding of participants and personnel (performance bias)	High risk	Following baseline measurements, neither staff nor participants were blinded to participants' allocation
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Patrick (2013)

Methods	Randomised Controlled Trial
Participants	101 participants; Adolescents (12-16 yo) at high risk of diabetes; United States of America
Interventions	52 weeks (1 year); INTERVENTION: divided in three (1) Web+SMS received 3 SMS per week, plus access to website and tutorials to promote weight loss and healthy behaviours, (2) access to website and tutorials, (3) access to website and tutorials pus

	90-minutes group sessions, CONTROL: received printed material produced by the American Diabetes Association and the American Heart Association (usual care); Library development not reported; Use of tailored communication not reported; No feedback provision; Bidirectional communication; Behavioural determinants and trans-theoretical model
Outcomes	BMI z-score
Notes	Drop out: 2/22 (9.09%) intervention, 5/26 (19.23%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Only mentions participants were randomised, however it does not give details on how this was done.
Allocation concealment (selection bias)	Unclear risk	Insufficient information to assess this risk.
Blinding of participants and personnel (performance bias)	Unclear risk	Insufficient information to assess this risk.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Prestwich (2009)

Methods	Randomised Controlled Trial
Participants	155 participants; Students (18-40 yo) exercising less than 3 times per week; United Kingdom

Interventions	4 weeks; INTERVENTION: divided in three (1) Group formed implementation intentions and received exercise SMS reminders (3.7 messages per week on average), I2: Group formed implementation intentions, I3: Group received exercise SMS reminders, Control: Group did not form implementation intentions and did not receive exercise SMS reminders; Participants developed their own messages; Tailored communication; No feedback provision; Unidirectional communication; Protection motivation theory and implementation intentions.
Outcomes	Exercise
Notes	Drop out: Not reported

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-based random number generator was used to allocate participants to conditions.
Allocation concealment (selection bias)	Low risk	No selection bias identified.
Blinding of participants and personnel (performance bias)	Unclear risk	Insufficient information to assess this outcome.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Prestwich (2010)

Methods	Randomised Controlled Trial
Participants	149 participants; people exercising less than 3 times per week (M=23.44 yo); United Kingdom
Interventions	4 weeks; INTERVENTION: divided in 2, (1) group formed implementation intentions and received SMS reminding them of their PA plans, (2) group formed implementation intentions and received SMS reminding them of their PA goals, CONTROL: group did not form implementation intentions and did not receive SMS, instead were informed of the governmental PA guidelines and were asked to try to walk for at least 30 min on 5 or more days per week; Participants constructed their own messages; Tailored communication; No feedback provision; Unidirectional communication; Implementation intentions.
Outcomes	Number of days exercised (including brisk/fast walking for >= 30 min)
Notes	Drop out: (1) 7/47 (14.89%), (2) 4/52 (7.69%), 4/50 (8%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocation sequence with no restrictions using a computer-generated randomisation program.
Allocation concealment (selection bias)	Low risk	Use of numbered and sealed envelopes prepared by a research staff member, who then passed it to another research member of staff who met with participants.

Blinding of participants and personnel (performance bias)	Low risk	Participants opened the envelopes in individual cubicles away from research staff.
Blinding of outcome assessment (detection bias)	Low risk	Participants (by not discussing the trial with others), Research staff entering the data and doing the statistical analysis were blinded to condition.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Schwerdtfeger (2012)

Methods	Pilot
Participants	63 participants; Adults (18-34 yo) not exercising extensively on a regular basis; Austria
Interventions	2 weeks; INTERVENTION: divided in 2 (1) solitary session grounded on SCT and implementation intentions aimed to encourage increase of PA + SMS reminders of action plans, (2) solitary session that grounded on SCT and implementation intentions where participants formed intentions, CONTROL: solitary session aimed to encourage increase of PA; Library development not reported; Untailored communication; No feedback provision; Unidirectional communication; Social cognitive theory and implementation intentions.
Outcomes	BMI
Notes	Drop out: none

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Mentions randomisation but it is unclear how this was done.
Allocation concealment (selection bias)	Unclear risk	No enough information to assess this bias.
Blinding of participants and personnel (performance bias)	Unclear risk	Participants in both intervention arms were not informed beforehand about their membership in one of the two intervention groups, but they were told that some of them would receive SMS.
Blinding of outcome assessment (detection bias)	Unclear risk	No enough information to assess this bias.
Incomplete outcome data (attrition bias)	High risk	Missing information.
Selective reporting (reporting bias)	High risk	Reporting results of ANOVAs of physical activity, but not the actual numbers. The outcome of interest (PA) is reported incomplete and cannot be entered in a meta-analysis.
Other bias	Low risk	No other bias identified.

Shapiro (2008)

Methods	Pilot
Participants	58 participants; Children (5-13)with no major metabolic problems associated with obesity; United States of America
Interventions	8 weeks; INTERVENTION: divided in 2, (1) SMS used to self-report pedometer usage, estimated sugar-sweetened beverage consumption, and estimated screen time daily (7 SMS per

	week), (2) same behaviours self-reported on physical diary, CONTROL: not self-reporting; Library development not reported; Use of tailored communication not applicable; Feedback provision; Bidirectional communication; Self-monitoring
Outcomes	Step count
Notes	Drop out: 5/18 (27.78%) intervention, 11/22 (50) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Use of uniform random number generator.
Allocation concealment (selection bias)	Low risk	No allocation concealment bias identified.
Blinding of participants and personnel (performance bias)	Low risk	Members of watch group met only with others in the same condition.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Shapiro (2012)

Methods	Randomised Controlled Trial
Participants	170 participants; Obese or overweight adults (21-65 yo); USA
Interventions	52 weeks (1 year);

	INTERVENTION: received SMS and MMS (28 per week) and additional material, CONTROL: same as intervention except for SMS and MMS and access to intervention website; Library development not reported; Tailored communication; Feedback provision; Bidirectional communication; Social cognitive theory
Outcomes	Weight loss
Notes	Drop out: 24/81 (29.6%) intervention, 16/89 (17.98%) control

Risk of bias table

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Allocation concealed via random number generator.
Allocation concealment (selection bias)	Low risk	Allocation concealed via random number generator and sealed envelopes by a researcher not involved with this study.
Blinding of participants and personnel (performance bias)	High risk	Neither the researchers at endpoint nor the statistician was blind to condition.
Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Shaw & Bosworth (2012)

Methods	Randomised Controlled Trial
Participants	120 participants; Obese or overweight adults (M=52 yo); United States of America
Interventions	12 weeks; INTERVENTION: divided in 2 (1) prevention SMS, (2) promotion SMS, CONTROL: general health messages (7 per week for 30 days); Library developed using current diet and exercise guidelines; Untailored communication; No feedback provision, Unidirectional; Regulatory focus theory
Outcomes	Weight
Notes	Dropout: (1) 8/40 (20%), (2) 4/41 (9.76%), 6/39 (15.38%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Used permuted block randomisation
Allocation concealment (selection bias)	Unclear risk	No enough information to assess this bias.
Blinding of participants and personnel (performance bias)	Unclear risk	No enough information to assess this bias.
Blinding of outcome assessment (detection bias)	Unclear risk	No enough information to assess this bias.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Sirriyeh (2010)

Methods	Randomised Controlled Trial
Participants	128 participants; Adolescents (16-19 yo); United Kingdom
Interventions	2 weeks; INTERVENTION: divided in 3 (1) affective SMS promoting PA; (2): cognitive SMS promoting PA; (3): affective and cognitive SMS promoting PA; all interventions received 7 SMS per week, CONTROL: control message (1 SMS per week); Library developed based on McEochan and using face validity; Untailored communication; No feedback provision; Unidirectional communication; Theory of planned behaviour
Outcomes	MET minutes
Notes	Drop out: (1) 1/32 (3.13%), (2) 1/31 (3.23), (3) 2/33 (6.06%), 4/32 (12.50%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Use of random number generator.
Allocation concealment (selection bias)	Low risk	Neither researcher nor participant had any knowledge of who was allocated to which group as the questionnaires were coded by group by an independent researcher.
Blinding of participants and personnel (performance bias)	Low risk	No performance bias identified.

Blinding of outcome assessment (detection bias)	Low risk	No detection bias identified.
Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Steinberg (2013)

Methods	Randomised Controlled Trial
Participants	50 participants; Obese women (25-50 yo); United States of America
Interventions	24 weeks (6 months); INTERVENTION: SMS messages (7 per week) and additional material, CONTROL: additional material, no SMS; Library development not reported; Tailored communication; Feedback provision; Bidirectional communication; Self-monitoring
Outcomes	Weight
Notes	Drop out: 1/26 (3.85%) intervention, 4/24 (16.67%) control

Risk of bias table

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants randomised using a computer-generated algorithm.
Allocation concealment (selection bias)	Unclear risk	No enough information to assess this bias.
Blinding of participants and personnel (performance bias)	Unclear risk	No enough information to assess this bias.
Blinding of outcome assessment (detection bias)	Unclear risk	Insufficient No enough information to assess this bias.

Incomplete outcome data (attrition bias)	Low risk	No attrition bias identified.
Selective reporting (reporting bias)	Low risk	No reporting bias identified.
Other bias	Low risk	No other bias identified.

Appendix A2 – Studies excluded from the systematic review with reasons.

Aguilera (2011)

Reason for exclusion	The study is not about weight nor physical activity.

Akopian (2011)

Reason for exclusion	Not an SMS intervention.

Antypas (2014)

Reason for exclusion	The main component of the intervention is a website. SMS only used as a reminder. The same information sent through SMS was also sent through the email.

Bauer (2010)

Reason for exclusion	No control group.

Connelly (2011)

Reason for exclusion	No control group.

De Niet (2012)

Reason for exclusion	The main focus of the study was dropout rate. Results of BMI (as a secondary measurement) were already reported in a study included in the review.

Donaldson (2014)

Reason for exclusion	Intervention measurements were compared to a retrospective control group offered weight checks only.

Fjeldsoe (2010)

Reason for exclusion	Interventions for experimental group and control differ.

Fjeldsoe (2015)

Reason for exclusion	Interventions for experimental group and control differ.

Fortune (2012)

Reason for exclusion	This is a negative study not reporting results.

Free (2013)

Reason for exclusion	Comment on a study.

Gerber (2009)

Reason for exclusion	No control group.

Haines (2013)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Hebden (2014)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Hung (2007)

Reason for exclusion	No results or evaluation of the intervention done.

Hurling (2007)

Reason for exclusion	A website is used as the main delivery medium. Difficult to account for the effect of SMS, as information and messages were also sent through email.

Joo (2007)

Reason for exclusion	No control group.

Kim (2006)

Reason for exclusion	No control group.

Kim (2007)

Reason for exclusion	Not reporting a change in physical activity.

Kim (2008)

Reason for exclusion	No physical activity or weight outcome reported

Kim (2008)

Reason for exclusion	Not using SMS.

King (2013)

Reason for exclusion	Apps intervention, not SMS.

Kolodziejczyk (2013)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Kornman (2010)

Reason for exclusion	No assessment made over weight reduction, but on adolescent and facilitator participation in a 10-month SMS and email obesity management intervention.

Lee (2011)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Lin (2014)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Lombard (2010)

Reason for exclusion	Intervention group and control were very different, which made it difficult to account for the effect of SMS.

Maddison (2014)

Reason for exclusion	Cannot account for the effect of SMS alone in this intervention.

McGraa (2010)

Reason for exclusion	Unable to access paper. Requested through the library document supply platform, but was unable to provide this study because it is a North American Thesis.

Mistry (2015)

Reason for exclusion	The outcome of this study was quantity and quality of action plans, but no behavioural outcome as exercise measured as MET, number of steps, minutes, etc.

Mutsuddi (2011)

Reason for exclusion	Unable to access paper. Requested through the library document supply platform, but was unable to provide this study because it is a North American Thesis.

Napolitano (2013)

Reason for exclusion	Intervention group and control were different, which made it difficult to account for the effect of SMS.

Nollen (2014)

Reason for exclusion	Not using SMS as a delivery medium.

Park (2009)

Reason for exclusion	The intervention uses websites and SMS. It is difficult to isolate the contribution or SMS effect on intervention outcome.

Park (2012)

Reason for exclusion	It is unclear what the role of SMS is in this intervention.

Radhakrishnan (2014)

Reason for exclusion	Intervention does not use SMS as a delivery medium.

Price (2015)

Reason for exclusion	No control group

Ram (2014)

Reason for exclusion	The study is aimed to a pre-diabetic population looking primarily into diabetes incidence.

Ramachandran (2013)

Reason for exclusion	The study is looking primarily into diabetes incidence.

Rossi (2010)

Reason for exclusion	No control group.

Shaw (2013)

Reason for exclusion	No control group. Developmental phase of intervention included in the review.

Soureti (2011)

Reason for exclusion	Weight or physical activity were outcomes not considered for this intervention. The intervention focused on eating behaviours.

Sternfield (2010)

Reason for exclusion	The intervention uses Apps, not SMS.

Zolfaghari (2012)

Reason for exclusion	Long term-condition management (blood glucose level)

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Appendix B1 – Search strategy

OVID

1. overweight.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

2. obes*.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

3. weight.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

4. weight loss.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

5. physical activity.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

6. exercis*.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

7. mobile.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

8. phone.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

9. mobile phone.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

10. smart phone.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

11. cell phone.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

12. cellular phone.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

13. text messag*.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

14. text*.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

15. txt.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

16. SMS.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

17. short message service.mp. [mp=ab, ti, ot, bt, hw, id, cc, nm, kf, px, rx, an, ui, tc, tm]

18. 1 or 2 or 3 or 4 or 5 or 6

19. 7 or 8 or 9 or 10 or 11 or 12

20. 13 or 14 or 15 or 16 or 17

21. 18 and 19 and 20

Web of Science

#23	#21 AND #20 Refined by: **LANGUAGES:** (ENGLISH) *DocType=All document types; Language=All languages;*
#22	#21 AND #20 *DocType=All document types; Language=All languages;*
#21	#20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 OR #13 OR #12 OR #11 OR #10 OR #9 *DocType=All document types; Language=All languages;*
#20	#8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1 *DocType=All document types; Language=All languages;*
#19	**TITLE:** (txt) *DocType=All document types; Language=All languages;*
#18	**TITLE:** (short message service) *DocType=All document types; Language=All languages;*
#17	**TITLE:** (sms) *DocType=All document types; Language=All languages;*
#16	**TITLE:** (text*) *DocType=All document types; Language=All languages;*
#15	**TITLE:** (text messag*) *DocType=All document types; Language=All languages;*
#14	**TITLE:** (cellular phone) *DocType=All document types; Language=All languages;*
#13	**TITLE:** (cell phone) *DocType=All document types; Language=All languages;*
#12	**TITLE:** (smart phone) *DocType=All document types; Language=All languages;*
#11	**TITLE:** (mobile phone) *DocType=All document types; Language=All languages;*

#10 **TITLE:** (phone)
DocType=All document types; Language=All languages;

#9 **TITLE:** (mobile)
DocType=All document types; Language=All languages;

#8 **TITLE:** (exercis*)
DocType=All document types; Language=All languages;

#7 **TITLE:** (inactivity)
DocType=All document types; Language=All languages;

#6 **TITLE:** (physical activity)
DocType=All document types; Language=All languages;

#5 **TITLE:** (weight management)
DocType=All document types; Language=All languages;

#4 **TITLE:** (weight loss)
DocType=All document types; Language=All languages;

#3 **TITLE:** (weight)
DocType=All document types; Language=All languages;

#2 **TITLE:** (obes*)
DocType=All document types; Language=All languages;

#1 **TITLE:** (overweight)
DocType=All document types; Language=All languages;

Scopus

((TITLE-ABS-KEY (overweight) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (obes*) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (weight) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (weight loss) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (physical activity) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (exercis*) AND PUBYEAR > 1999)) AND ((TITLE-ABS-KEY (mobile) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (phone) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (mobile phone) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (smart phone) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (cell phone) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (cellular phone) AND PUBYEAR > 1999)) AND ((TITLE-ABS-KEY (text messag*) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (text*) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (txt) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (sms) AND PUBYEAR > 1999) OR (TITLE-ABS-KEY (short message service) AND PUBYEAR > 1999)) AND (EXCLUDE (LANGUAGE , "Chinese") OR EXCLUDE (LANGUAGE , "German") OR EXCLUDE (LANGUAGE , "French") OR EXCLUDE (LANGUAGE , "Korean") OR EXCLUDE (LANGUAGE , "Italian") OR EXCLUDE (LANGUAGE , "Polish") OR EXCLUDE (LANGUAGE , "Portuguese") OR EXCLUDE (LANGUAGE , "Slovene"))

Appendix B2 – PRISMA checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	25
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	NA
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	25-29
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	29 – 30
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	29 – 30
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	30
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	221
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	31 – 32
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	32
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	28, 32
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	34 – 36
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	36
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	36 - 37

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	36
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	37 – 40
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	32
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	33
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	35
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	37
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	37
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	36
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	37 – 40
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	40 – 41
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	42
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	43
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	iii

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Appendix C – Recruiting materials

C.1 Study 1 recruiting materials

Study 1 – Sample recruitment poster

Study 1 – Sample recruitment flyer

Study 1 – Sample recruitment email

Subject: How do you react to words?
Attached: Participant Information Sheet.pdf

Hi! I am writing to invite you to participate in my doctoral study. I am investigating the reliability and validity of physiological measures to inform the design of emotionally significant text messages for global health promotion.

The experiment will take place in the Psychology of Design Laboratory of the Institute of Psychological Sciences. The total duration of the experiment is 1 hour. We are recruiting participants between 18 and 45 years old with good command of the English language, not suffering from any visual impairment, and not suffering from chronic neurological disorders including, but not limited to epilepsy, Parkinson's disease, tremors, diabetes, anxiety, and panic attacks.

Participants will receive £7.00 upon completion of the experiment as a sign of gratitude for their time.

All the information collected about you during the study will be kept strictly confidential. This study has been reviewed by the IPS Research Ethics Committee and has been approved (*reference number:* 13-0140; *date approved:* 15-Oct-2013.). The attached document contains more information regarding the study. Please contact me if you have any queries.

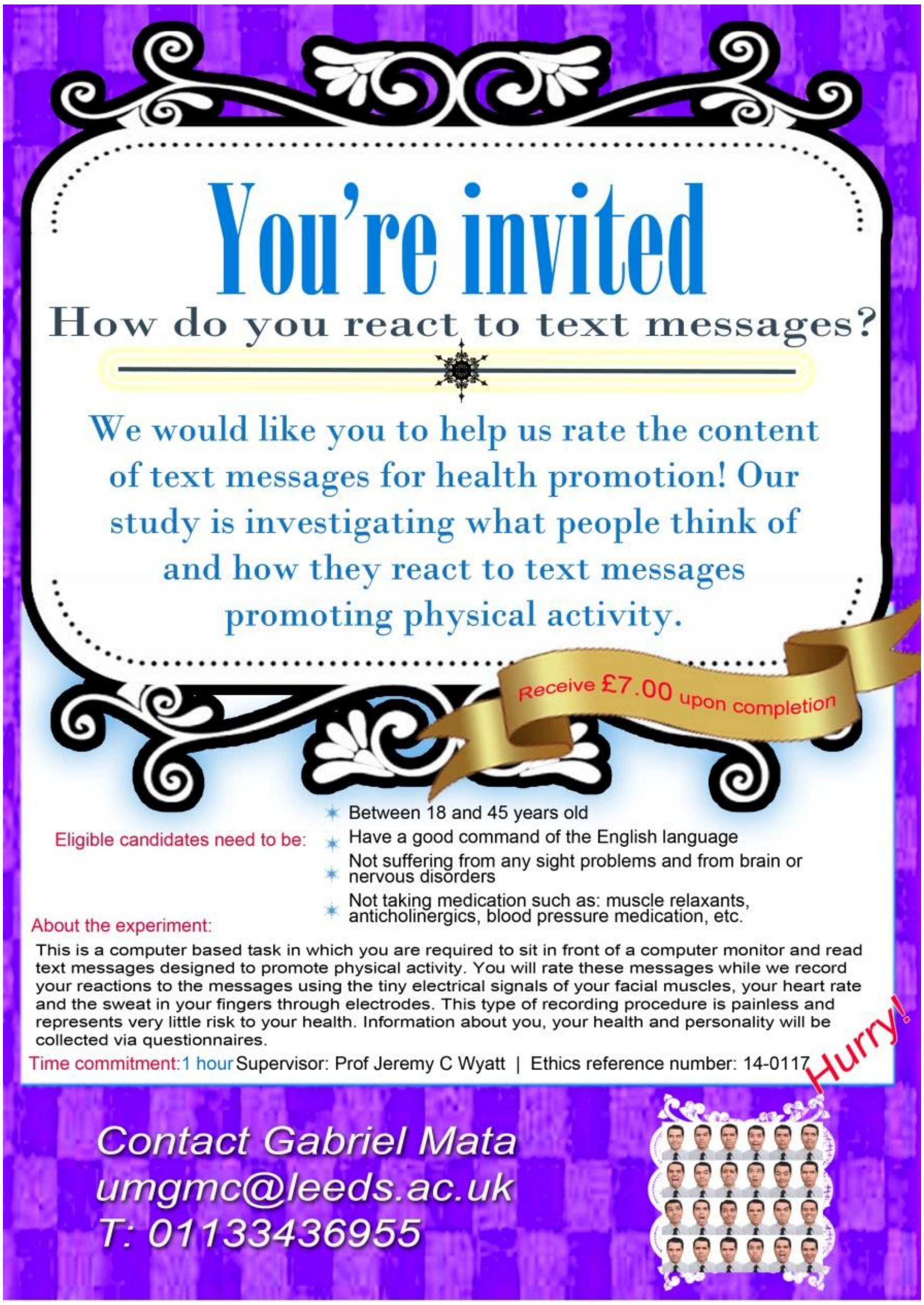
Best wishes,
Gabriel Mata-Cervantes
PhD Student

Yorkshire Centre for Health Informatics
Leeds Institute of Health Sciences
University of Leeds
Charles Thackrah Building
Room G.02
101 Clarendon Road
Leeds
LS2 9LJ
E: umgmc@leeds.ac.uk
T: +44 (0) 113 343 6955

C.2 Study 2 recruiting materials

Study 2 – Sample recruitment poster

Study 2 – Sample recruitment flyer



Study 2 – Sample recruitment email

Subject: Can text messages be emotional?
Attached: Participant Information Sheet.pdf

Hi! I am writing to invite you to participate in my doctoral research study. I am investigating people's physiological response towards health promotion text messages.

The experiment will take place in the Psychophysiology Laboratory (Room B.18c) in the Institute of Psychological Sciences. The total duration of the experiment is one hour. We are recruiting participants between 18 and 45 years old with good command of the English language, not suffering from any visual impairment, and not suffering from chronic neurological disorders including, but not limited to epilepsy, Parkinson's disease, tremors, diabetes, anxiety, and panic attacks.

Participants will receive £7.00 upon completion of the experiment as a sign of gratitude for their time.

The experiment consists of a computer based task in which you will be asked to read text messages and rate them in terms of arousal (how stimulated, excited, aroused or relaxed, calmed and unaroused you felt) and pleasure (how happy, pleased, confident or unhappy, annoyed, bored you felt). The text messages will be presented one at a time for 6 seconds on a computer screen and after that you will be asked to rate them. While you do this we will be recording your physiological responses using electrodes attached to your face, fingers, wrist and ankle. This type of recording procedure is completely painless and represents very little risk to your health. Information about you, your health and your personality will be collected via questionnaires.

All the information collected about you during the study will be kept strictly confidential. This study has been reviewed by the IPS Research Ethics Committee and has been approved (*reference number:* 14-0117; *date approved:* 27-Jun-2014. *Supervisor:* Prof Jeremy C Wyatt). The attached document (Participant Information Sheet) contains more information regarding the study. Please contact me if you are interested in taking part in the study or if you have any queries.

Gabriel Mata-Cervantes
PhD Student

Yorkshire Centre for Health Informatics
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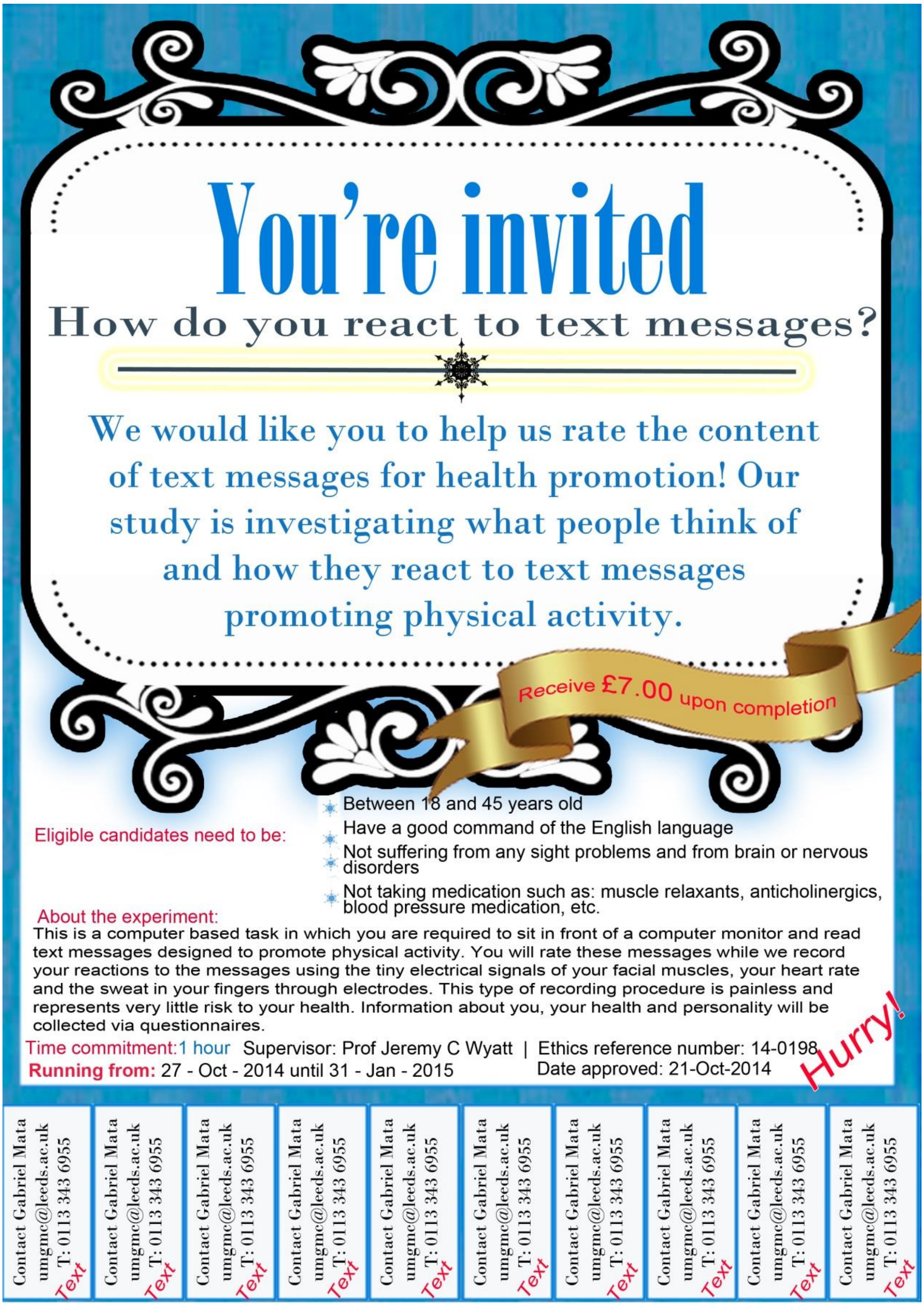
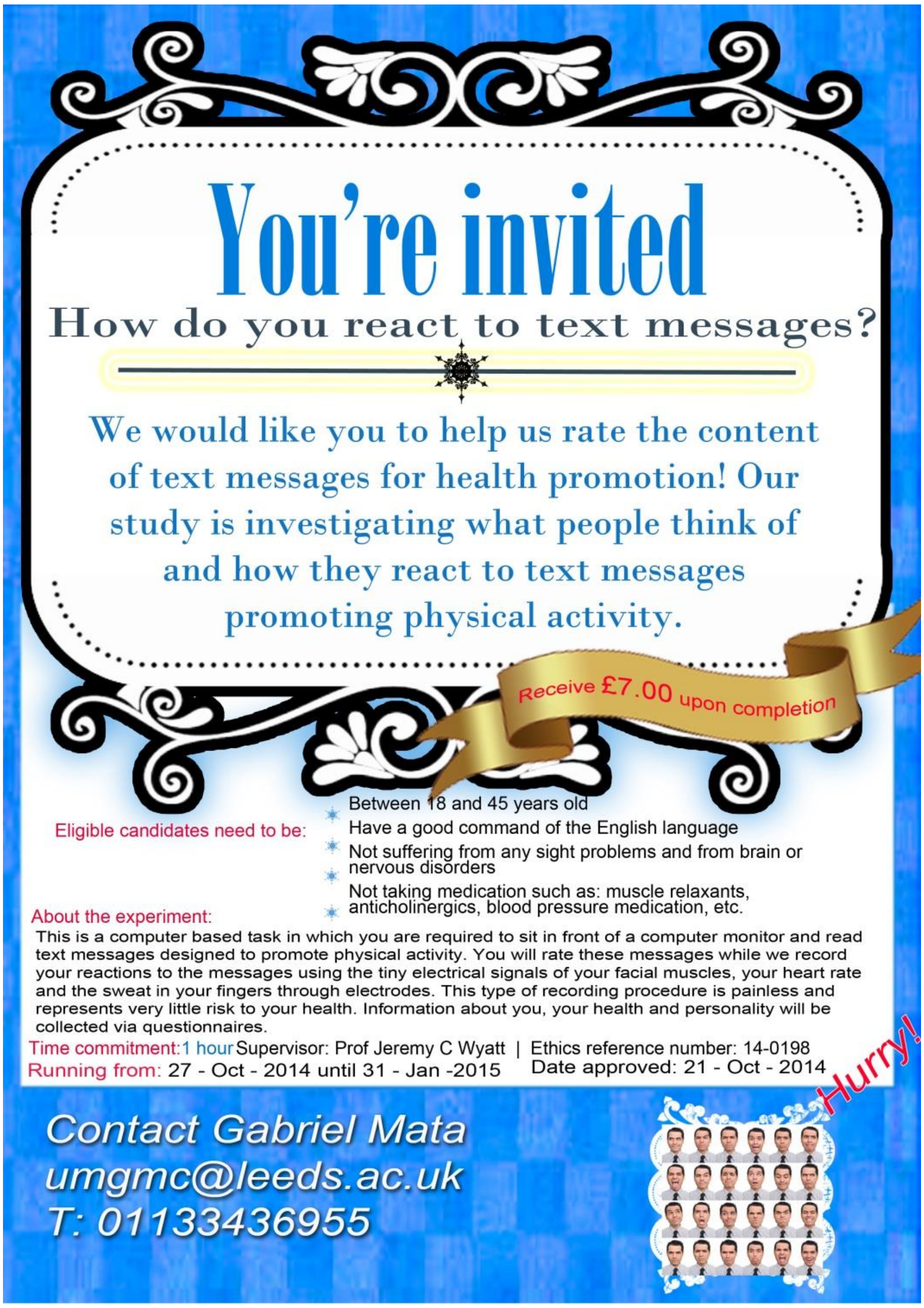
E: umgmc@leeds.ac.uk
T: +44 (0) 113 343 6955

C.3 Study 3 recruiting materials

Study 3 – Sample recruitment poster

Study 3 – Sample recruitment flyer




You're invited
How do you react to text messages?
We would like you to help us rate the content of text messages for health promotion! Our study is investigating what people think of and how they react to text messages promoting physical activity.
Receive £7.00 upon completion
Eligible candidates need to be:
Between 18 and 45 years old
Have a good command of the English language
Not suffering from any sight problems and from brain or nervous disorders
Not taking medication such as: muscle relaxants, anticholinergics, blood pressure medication, etc.
About the experiment:
This is a computer based task in which you are required to sit in front of a computer monitor and read text messages designed to promote physical activity. You will rate these messages while we record your reactions to the messages using the tiny electrical signals of your facial muscles, your heart rate and the sweat in your fingers through electrodes. This type of recording procedure is painless and represents very little risk to your health. Information about you, your health and personality will be collected via questionnaires.
Time commitment: 1 hour Supervisor: Prof Jeremy C Wyatt | Ethics reference number: 14-0198
Running from: 27 - Oct - 2014 until 31 - Jan -2015 Date approved: 21 - Oct - 2014
Hurry!
Contact Gabriel Mata
umgmc@leeds.ac.uk
T: 01133436955

Study 3 – Sample recruitment email

Subject: Can text messages be emotional?
Attached: Participant Information Sheet.pdf

Hi! I am writing to invite you to participate in my doctoral research study. I am investigating people's physiological response towards health promotion text messages.

The experiment will take place in the Psychophysiology Laboratory (Room B.18c) in the Institute of Psychological Sciences. The total duration of the experiment is one hour. We are recruiting participants between 18 and 45 years old with good command of the English language, not suffering from any visual impairment, and not suffering from chronic neurological disorders including, but not limited to epilepsy, Parkinson's disease, tremors, diabetes, anxiety, and panic attacks.

Participants will receive £7.00 upon completion of the experiment as a sign of gratitude for their time.

The experiment consists of a computer based task in which you will be asked to read text messages and rate them in terms of pleasure (how happy, pleased, confident or unhappy, annoyed, bored you felt), arousal (how stimulated, excited, aroused or relaxed, calmed and unaroused you felt) and their likeliness of persuading you to engage in physical activity. The text messages will be presented one at a time on a computer screen and you will then be asked to rate them. While you do this we will be recording your physiological responses using electrodes attached to your face, fingers, wrist and ankle. This type of recording procedure is completely painless and represents very little risk to your health. Information about you, your health and your personality will be collected via questionnaires.

All the information collected about you during the study will be kept strictly anonymous. This study has been reviewed by the IPS Research Ethics Committee and has been approved (reference number: 14-0198; date approved: 21-Oct-2014. Supervisor: Prof Jeremy C Wyatt). The attached document (Participant Information Sheet) contains more information regarding the study. Please contact me if you are interested in taking part in the study or if you have any queries.

Gabriel Mata-Cervantes
PhD Student

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Appendix D – Participant Information Sheets

Study 1 – Participant Information Sheet

Version:	2.0
Last revision:	15/10/2013
Principal Investigator:	Gabriel Mata-Cervantes (umgmc@leeds.ac.uk)
Supervisory Team:	*Prof Jeremy C Wyatt*, main supervisor (J.C.Wyatt@leeds.ac.uk) Prof Andrew J Hill Dr Steve Westerman Dr Melanie Burke
Address:	*Leeds Institute of Health Sciences* 101 Clarendon Road University of Leeds Leeds, West Yorkshire LS2 9LJ
Contact details:	E: umgmc@leeds.ac.uk T: 0113 343 6945

I am a Doctoral candidate at the University of Leeds, sponsored by the Mexican National Council for Science and Technology (CONACyT). I am interested in the role of emotions in the design of SMS text messages for global health promotion.

I would like to invite you to participate in our study. The aim is to design emotionally significant text messages. This study is investigating how accurate physiological measures are to inform the design of SMS text messages for behaviour change. We are recruiting participants between 18 and 45 years old with a good command of the English language, not suffering from any sight problems, and not suffering from brain or nervous disorders (e.g. epilepsy, Parkinson's disease, tremor, diabetes, anxiety, and panic attacks).

The experiment is a computer based task. You will be asked to look five times at a set of everyday words and words related to exercise (presented one at a time and for 6 seconds each) on a computer screen. We will also ask you to press any key from the keyboard every time you read a nonsense word while we record your emotional response to the words using the tiny electrical signals in your muscles and the sweat in your fingers. This type of recording procedure is painless and represents no risk to your health. Overall, the whole set-up and test will take about 1 hour. The experiment will take place in the Psychology of Design Laboratory of the Institute of Psychological Sciences at the University of Leeds.

If you agree to take part we will ask you to sign a consent form. We will also ask you to fill in a questionnaire about your health beliefs, mood, self-perception, etc. All the information collected about you will be anonymised, guaranteeing that you cannot be recognised. You are free to withdraw at any stage of the study without giving a reason as your participation is voluntary. The results and knowledge stemming from this study are intended to be used in publications and conferences.

This study has been reviewed by the IPS Research Ethics Committee and has been approved (ref no: 13-0140; date approved: 15–Oct–2013). It is subject to ethical guidelines set out by the British Psychological Society. These guidelines include principles such as obtaining your informed consent before participation, notifying you of your right to withdraw, and protection from any risk or harm. This sheet has hopefully provided you with enough information about the study to allow you make an informed decision about participation. However, if you have any questions or would like to discuss anything further feel free to contact us either via email or phone using the details above

Study 2 – Participant Information Sheet

Version:	2.0
Last revision:	28/04/2014
Principal Investigator:	Gabriel Mata-Cervantes
Supervisory Team:	*Prof Jeremy C Wyatt* (J.C.Wyatt@leeds.ac.uk) Prof Andrew J Hill Dr Steve Westerman Dr Melanie Burke
Address:	*Leeds Institute of Health Sciences* 101 Clarendon Road University of Leeds Leeds, West Yorkshire LS2 9LJ
Contact details:	E: umgmc@leeds.ac.uk T: 0113 343 6945

I am a Doctoral candidate at the University of Leeds, sponsored by the Mexican National Council for Science and Technology (CONACyT), interested in people's physiological responses to SMS text messages for health promotion.

I would like to invite you to participate in my second study aimed at assessing text messages promoting physical activity. This study will assess the content of the text messages through participant's ratings and physiological responses. We are recruiting participants between 18 and 45 years old with a good command of the English language, not suffering from any visual impairment, and not suffering from chronic neurological disorders including, but not limited to epilepsy, Parkinson's disease, tremor, diabetes, anxiety, and panic attacks.

The experiment is a computer based task in which you will be asked to read text messages and rate them in terms of arousal (how stimulated, excited, aroused or relaxed, calmed and unaroused you felt) and pleasure (how happy, pleased, confident or unhappy, annoyed, bored you felt). The text messages will be presented one at a time for 6 seconds on a computer screen and after that you will be asked to rate them. While you do this we will be recording your physiological responses using electrodes attached to your face, fingers, wrist and ankle. This type of recording procedure is completely painless and represents very little risk to your health.

The experiment will take place in the Psychophysiology Laboratory of the Institute of Psychological Sciences at the University of Leeds. Overall, the whole set-up and test will take no longer than 1 hour to complete.

If you agree to take part we will ask you to sign a consent form. We will also collect important information about you, your health and your personality through some questionnaires. All the information collected about you will be anonymised, guaranteeing that you cannot be recognised. You are free to withdraw at any stage of the study without giving a reason as your participation is voluntary. The results and knowledge stemming from this study are intended to be used in publications and conferences.

This research is subject to ethical guidelines set out by the British Psychological Society. These guidelines include principles such as obtaining your informed consent before participation, notifying you of your right to withdraw, and protection from any risk or harm. This sheet has hopefully provided you with enough information about the study to allow you make an informed decision about participation. However, if you have any questions or would like to discuss anything further feel free to contact us either via email or phone using the details above.

Study 3 – Participant Information Sheet

Version: 3.0
Last revision: 07/10/2014
Principal Investigator: Gabriel Mata-Cervantes
Supervisory Team: *Prof Jeremy C Wyatt* (J.C.Wyatt@leeds.ac.uk)
Prof Andrew J Hill
Dr Ed Sutherland
Dr Melanie Burke
Address: *Leeds Institute of Health Sciences*
101 Clarendon Road
University of Leeds
Leeds, West Yorkshire LS2 9LJ
Contact details: E: umgmc@leeds.ac.uk
T: 0113 343 6945

I am a Doctoral candidate at the University of Leeds, sponsored by the Mexican National Council for Science and Technology (CONACyT), interested in people's physiological responses to SMS text messages for health promotion.

I would like to invite you to participate in a study aimed to assess text messages promoting physical activity. This study will assess the content of the text messages through participant's ratings and physiological responses. We are recruiting participants between 18 and 45 years old with a good command of the English language, not suffering from any visual impairment, and not suffering from chronic neurological disorders including, but not limited to epilepsy, Parkinson's disease, tremor, diabetes, anxiety, and panic attacks.

The experiment is a computer based task in which you will be asked to read text messages and rate them in terms of pleasure (how happy, pleased, confident or unhappy, annoyed, bored you felt), arousal (how stimulated, excited, aroused or relaxed, calmed and unaroused you felt) and their likeliness of persuading you to engage in physical activity. The text messages will be presented one at a time on a computer screen and after that you will be asked to rate them. While you do this we will be recording your physiological responses using electrodes attached to your face, fingers, wrist and ankle. This type of recording procedure is completely painless and represents very little risk to your health.

The experiment will take place in the Psychophysiology Laboratory of the Institute of Psychological Sciences at the University of Leeds. Overall, the whole set-up and test will take no longer than 1 hour to complete.

If you agree to take part we will ask you to sign a consent form. We will also collect important information about you, your health and your personality through some questionnaires. All the information collected about you will be anonymised, guaranteeing that you cannot be recognised. You are free to withdraw at any stage of the study without giving a reason, as your participation is voluntary. The results and knowledge stemming from this study are intended to be used in publications and conferences.

This research is subject to ethical guidelines set out by the British Psychological Society. These guidelines include principles such as obtaining your informed consent before participation, notifying you of your right to withdraw, and protection from any risk or harm. This sheet has hopefully provided you with enough information about the study to allow you make an informed decision about participation. However, if you have any questions or would like to discuss anything further feel free to contact us either via email or phone using the details above

Appendix E – Informed Consent Form

CONSENT FORM

Thank you very much for agreeing to take part in this research. The purpose of this form is to make sure that you are happy to take part in the research and that you know what is involved. Please *write your initials* inside each box after reading and agreeing with each statement.

Title of Project: ______________________________

Name of Researcher: Gabriel Mata Cervantes

Version Number: _____

Please initial box

1. I confirm that I have read and understand the information sheet dated DD/MM/YYYY (version ……..) explaining the above research project. I have had the opportunity to consider the information, ask questions to a member of the research team and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐
3. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ☐
4. I agree for the data collected from me to be used in relevant future research. ☐
5. I agree to take part in the above named research project and will inform the lead researcher should my contact details change. ☐

	Participant	Researcher
Name (PRINT):	_______________________	_______________________
Signature:	_______________________	_______________________
Date:	_______________________	_______________________

Appendix F – Participant Health Information Form

Participant Health Information Form

Please fill the form in CAPITAL LETTERS with a black ink pen.

Family Name (Surname)			
Name(s)		*Title*	
Date of Birth DD/MM/YYYY	*Male* ☐	*Female* ☐	
Place of Birth	*Contact Phone*		
Email address			
Are you left or right-handed?	*Left* ☐	*Right* ☐	
Do you suffer from any known neurological illness? (e.g. multiple system atrophy, Parkinson's disease, essential tremor, etc.)	*Yes* ☐	*No* ☐	
Have you taken blood pressure medication, muscle relaxants or anticholinergics in the past 24 hours?	*Yes* ☐	*No* ☐	
Are you under any other medication?	*Yes* ☐	*No* ☐	

RESEARCH TEAM USE ONLY

☐ Signed Consent Form

☐ You and exercise questionnaire

☐ Self-perception and EBQ

Study No: ______

Session date: ____/____/____

RESEARCH TEAM USE ONLY

Comments:

Appendix G – Self-Perception and Eating Behaviour Questionnaire

Self-Perception and Eating Behaviour Questionnaire

Please answer the following questions as honestly as possible. Most questions simply need you to mark the box that best answers the question. Try not to leave any questions unanswered. If there is anything you don't understand please ask.

Question 1: How tall are you?

__________ m or ______ ft ______ in

Question 2: How much do you weigh?

__________ kg or _________ lb or _________ st

Question 3: Do you engage in any form of regular exercise?
(*Please keep in mind that regular exercise is here defined as accumulating at least 30 minutes of physical activity on at least 3 days of the week.)*

Yes	
No	

If No, go to question 5.

Question 4: How often do you exercise?

Less than three days a week	
Three days a week	
More than three days a week	
Every day	

Question 5: Do you feel yourself to be:

Very overweight	
Moderately overweight	
Slightly overweight	
About the right weight	
Slightly underweight	
Moderately underweight	
Very underweight	

Question 6: Which of the following would you describe yourself as?

Currently dieting to lose weight	
Currently dieting or watching what I eat so as not to put on weight	
Not dieting	

Appendix H – Debrief sheets

Study 1

Participant Debrief Sheet

Thank you for participating in our study!

The results of this study will be used to examine electrodermal activity (EDA) and facial electromyography (fEMG), as measurements to develop health promotion SMS text messages. This is the first of a series of three studies aimed to determine if using these physiological measurements add value to conventional development methods, such as focus groups.

Systematic reviews of studies using SMS text messages as the main delivery method for behaviour change interventions have shown that text messages are sometimes effective. Research has identified important variables to be considered for an SMS intervention design to ensure a greater impact. These variables include duration, delivery frequency, source of the message, feedback, and message tailoring. Neuhauser and Kreps showed that tailored communication is more effective when it reaches people on an emotional level as well as a rational level.

Understanding people and how they react to stimuli by measuring their biometrics is the foundation of neuromarketing, a concept originated by psychologists in Harvard University.

We believe that using neuromarketing methods, specifically EDA and fEMG will help us better understand the likely effect a message will have on the receiver. This means that we should be able to produce more persuasive and engaging text messages than using conventional methods for promoting healthier habits.

If you have any additional questions regarding this research or if you would like to receive a summary report of the study findings, please feel free to ask or contact us using the information below.

Once again, thank you for your participation.

Gabriel Mata-Cervantes
PhD candidate, University of Leeds, UK
E: umgmc@leeds.ac.uk
T: 0113 343 6945

Prof Jeremy C. Wyatt
Leadership chair in eHealth research (health informatics)
Yorkshire Centre for Health Informatics
Leeds Institute of Health Sciences, University of Leeds, UK
E: J.C.Wyatt@leeds.ac.uk

Study 2

Participant Debrief Sheet

Thank you for participating in our study!

The results of this study will be used to determine the arousal and valence associated with the SMS text messages you have read and assessed. The psychophysiology techniques used in this experiment will allow us to measure the level of arousal and valence that the messages elicited in you. Your ratings will help us determine if what you rated is how your body reacted. This is the second of a series of three studies aimed to determine if using these physiological measurements add value to conventional development methods for text messages for health promotion, such as focus groups.

Systematic reviews of studies using SMS text messages as the main delivery method for behaviour change interventions have shown that text messages are sometimes effective. Research has identified important variables to be considered for an SMS intervention design to ensure a greater impact. These variables include duration, delivery frequency, source of the message, feedback, and message tailoring. Neuhauser and Kreps showed that tailored communication is more effective when it reaches people on an emotional level as well as a rational level.

Understanding people and how they react to messages by measuring their physiological responses is the foundation of neuromarketing, a concept originated by psychologists in Harvard University. We believe that using neuromarketing methods, specifically electrodermal activity, facial electromyography and heart rate variability will help us better understand the likely effect a text message has on the receiver. This means that we should be able to produce more persuasive and engaging text messages than using conventional methods for promoting healthier habits.

If you have any additional questions regarding this research or if you would like to receive a summary report of the study findings, please feel free to ask or contact us using the information below.

Once again, thank you for your participation.

Gabriel Mata Cervantes
PhD candidate, University of Leeds, UK
E: umgmc@leeds.ac.uk
T: 0113 343 6945

Prof Jeremy C. Wyatt
Leadership chair in eHealth research (health informatics)
E: J.C.Wyatt@leeds.ac.uk

Study 3

Participant Debrief Sheet

Thank you for participating in our study!

The results of this study will be used to determine the arousal and valence associated with the SMS text messages you have read and assessed. The psychophysiology techniques used in this experiment will allow us to measure the level of arousal and valence that the messages elicited in you. Your ratings will help us determine if what you rated is how your body reacted. This is the final study in a series of studies aimed to determine if using these physiological measurements add value to conventional development methods for text messages for health promotion, such as focus groups.

Systematic reviews of studies using SMS text messages as the main delivery method for behaviour change interventions have shown that text messages are sometimes effective. Neuhauser and Kreps showed that tailored communication is more effective when it reaches people on an emotional level as well as a rational level. Research has identified important variables to be considered for an SMS intervention design to ensure a greater impact. These variables include duration, delivery frequency, source of the message, feedback, and message tailoring. Effective tailoring variables reported by Fjeldsoe et al (2009) include name or nickname, age, gender, behavioural history, behavioural goal, and behavioural preferences, among others. This is why we tested some messages using your name, your preferred physical activity and a combination of both.

Understanding people and how they react to messages by measuring their physiological responses is the foundation of neuromarketing, a concept originated by psychologists in Harvard University. We believe that using neuromarketing methods – specifically electrodermal activity, facial electromyography and heart rate variability – will help us better understand the likely effect a text message has on the receiver. This means that we should be able to produce more persuasive and engaging text messages than using conventional methods for promoting healthier habits.

If you have any additional questions regarding this research or if you would like to receive a summary report of the study findings, please feel free to ask or contact us using the information below.

Once again, thank you for your participation.

Gabriel Mata Cervantes
PhD candidate, University of Leeds, UK
E: umgmc@leeds.ac.uk
T: 0113 343 6945

Prof Jeremy C. Wyatt
Leadership chair in eHealth research (health informatics)
E: J.C.Wyatt@leeds.ac.uk

Appendix I – Ethical approval emails

Study 1

From: Melanie Burke
Sent: 31 January 2014 09:53
To: Gabriel Mata Cervantes
Subject: FW: Ethics form decision

-----Original Message-----
From: Ethics.Committee@webhost02h.leeds.ac.uk
[mailto:Ethics.Committee@webhost02h.leeds.ac.uk]
Sent: 20 August 2013 13:16
To: pscmrb@leeds.ac.uk
Subject: Ethics form decision

Melanie Burke
Institute of Psychological Sciences
University of Leeds
Leeds LS2 9JT
20-Aug-2013

Dear Melanie Burke,

Title of study: Assessing the reliability and validity of electrodermal activity and facial electromyography as methods to inform SMS text messages interventions for global health promotion in people between 18 and 45 years old.

Ethics reference: 13-0140

I am pleased to inform you that the above research application has been reviewed by the IPS Research Ethics Committee and has been approved.
Please note that this approval only relates to the particular version of documentation supplied in this specific application (ref no: 13-0140; date approved: 20-Aug-2013). If you wish to make any amendments to the approved documentation, please note that all changes require ethical approval prior to implementation.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes.
You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://researchsupport.leeds.ac.uk/index.php/academic_staff/good_practice/managing_approved_projects-1/ethics_audits-1

Yours sincerely,

IPS Research Ethics Committee
(Chair: Dr Amanda Waterman)

Study 2

From: Melanie Burke
Sent: 30 June 2014 09:31
To: Stephen Westerman; Gabriel Mata Cervantes
Subject: FW: Ethics form decision

Ethics = approved.

Well done,

Mel

-----Original Message-----
From: Ethics.Committee@webhost02h.leeds.ac.uk
[mailto:Ethics.Committee@webhost02h.leeds.ac.uk]
Sent: 27 June 2014 16:02
To: Melanie Burke
Subject: Ethics form decision

Melanie Burke
Institute of Psychological Sciences
University of Leeds
Leeds LS2 9JT
27-Jun-2014

Dear Melanie Burke,

Title of study: Comparing psychophysiological responses of people reading affective and instrumental SMS text messages aimed to increase physical activity

Ethics reference: 14-0117

I am pleased to inform you that the above research application has been reviewed by the IPS Research Ethics Committee and has been approved.
Please note that this approval only relates to the particular version of documentation supplied in this specific application (ref no: 14-0117; date approved: 27-Jun-2014). If you wish to make any amendments to the approved documentation, please note that all changes require ethical approval prior to implementation.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes.
You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits

Yours sincerely,

IPS Research Ethics Committee
(Chair: Donna Lloyd)

Study 3

From: Melanie Burke
Sent: 21 October 2014 16:37
To: Gabriel Mata Cervantes
Subject: Fwd: Ethics form decision

Hi Gabriel,

That was fast !!!! See ethics approval below.

Regards,

Mel

----- Forwarded message -----
From: "Ethics.Committee@webhost02h.leeds.ac.uk"
<Ethics.Committee@webhost02h.leeds.ac.uk>
To: "Melanie Burke" <M.R.Burke@leeds.ac.uk>
Subject: Ethics form decision
Date: Tue, Oct 21, 2014 16:29

Melanie Burke
Institute of Psychological Sciences
University of Leeds
Leeds LS2 9JT
21-Oct-2014

Dear Melanie Burke,

Title of study: Comparing psychophysiological reactions of people reading affective and instrumental SMS text messages aimed to increase physical activity

Ethics reference: 14-0198

I am pleased to inform you that the above research application has been reviewed by the IPS Research Ethics Committee and has been approved.
Please note that this approval only relates to the particular version of documentation supplied in this specific application (ref no: 14-0198; date approved: 21-Oct-2014). If you wish to make any amendments to the approved documentation, please note that all changes require ethical approval prior to implementation.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes.
You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits

Yours sincerely,

IPS Research Ethics Committee
(Chair: Donna Lloyd)

Appendix J – About you and exercise questionnaire

About You and Exercise

Question 1: Do you engage in any form of regular exercise?
(*Please keep in mind that* ***regular exercise*** *is here defined as accumulating at least 30 minutes of physical activity on at least 3 days of the week.)*

☐ Yes
☐ No (If you answered no, go to question 3)

Question 2: How often do you exercise?

☐ Less than three days a week
☐ Three days a week
☐ More than three days a week
☐ Every day

Question 3: From the list below select the physical activity(ies) that you normally engage in or would like to engage. If more than one, please number them in order of preference:

☐ aerobics
☐ brisk walking
☐ climbing (indoors/outdoors)
☐ cycling
☐ going to the gym
☐ gymnastics
☐ hiking
☐ jogging
☐ kick boxing
☐ pilates
☐ rowing
☐ running
☐ swimming
☐ tai chi
☐ yoga
☐ zumba
☐ other: ____________________

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