"When you have a great and difficult task, something perhaps almost impossible, if you only work a little at a time, every day a little, suddenly the work will finish itself."

Isak Dinesen (1885-1962)
This thesis is based on the Health Action Process Approach (HAPA) model as a theoretical framework to explain health behaviour change. The first part of this thesis presents the results of three online proof of principle studies evaluating different strategies targeting hypothesised determinants of saturated fat intake in a high CVD risk population. The second part of this thesis builds further on these results and describes the underlying social-cognitive mechanisms involved in bridging the risk-intention-behaviour gap. This final chapter starts by summarising the main findings presented so far, followed by a critical reflection of these findings and related methodological considerations. It finishes with suggestions for future research and implications for health promotion practice.

**Main findings**

In the first proof of principle study (Chapter 2), we compared new ways of communicating risk using a risk analogy (Heart-Age) against a % risk message - the most commonly used format at present- in obese and/or smoking adults. We found the Heart-Age risk message to be superior to the % CVD risk message in communicating risk, especially for those at higher CVD risk. For the younger participants the Heart-Age risk message was also more emotionally impactful. Intentions to change diet, physical activity and stop smoking did not differ significantly across the two conditions, though they were in favour of the Heart-Age risk message condition.

In the second proof of principle study (Chapter 3), both the motivational and volitional aspects of behaviour change in obese adults were targeted. The Heart-Age risk message was combined with planning, an effective self-regulatory strategy, with the aim of reducing consumption of foods high in saturated fat. Two measures of saturated fat intake were used: a) a two-item scale (TIS) assessing perceived saturated fat intake and b) % saturated fat intake assessed by a food frequency questionnaire (FFQ). Each condition independently showed beneficial effects on perceived saturated fat intake (TIS), though the combination was not more effective compared to the control group. In specific, participants allocated to the planning condition improved their perceived consumption of low saturated fat foods compared to the control group. However, no difference between groups in % saturated fat intake based on a FFQ was observed. Although, the Heart-Age risk message conditions did not significantly improve
behaviour compared to controls, individuals in these Heart-Age conditions with higher Heart-Ages, and thus higher actual risk, were more likely to perceive themselves as being at risk.

Since planning seemed to effectively change short-term behaviour, in the next proof of principle study (Chapter 4) we tried to boost the effects of the above-mentioned planning tool by adding short message service (SMS) reminders of plans in overweight adults. The primary outcome measure was again saturated fat intake assessed by the TIS and % saturated fat intake (FFQ). An additional measure was added; that of portion sizes. As hypothesized, there was a beneficial effect of planning and SMS reminders on portion sizes when compared to the control group. This was especially evident in men allocated to the planning and SMS reminder condition. Both experimental conditions further showed significantly greater reductions in perceived saturated fat (TIS) when compared to the control group. As with our previous study (Chapter 3), the effects of the experimental conditions were significant for the TIS scale, but not for % saturated fat.

In the second part of this thesis, data from the above studies were used to test the potential underlying mechanisms of behaviour change. For example, in Chapter 5, and based on the data from the second study (Chapter 3), we confirmed that planning acts as a mediator in the relationship between intentions and saturated fat intake reductions. We also found that this mediated effect was moderated by age, self-efficacy and intention. In younger individuals, high intenders and people with high levels of maintenance self-efficacy the association of planning and perceived saturated fat intake was stronger.

In Chapter 6, and based on the data from Chapter 2 and 3, we tested the mediating properties of worry and judgements of the intervention in the relationship between risk perceptions and intentions. Worry assessed the emotional impact of the intervention, while intervention judgements included items on the perceived credibility, enjoyability, personal relevance and interest of the study. Participants in both studies reported moderate levels of worry and risk perceptions, meaning that they were not unnecessarily worried by the risk messages. They also judged the intervention positively and showed high levels of intentions. Worry and intervention judgements were mediators in the relationship between risk perceptions and the
intention to eat healthier, the intention to do more physical activity (study 1, Chapter 2) and the intention to reduce saturated fat intake (study 2, Chapter 3). Worry was the only mediator in the relationship between risk perceptions and the intention to stop smoking (study 1, Chapter 2). In the last study (Chapter 7), we tested the value of the HAPA model in explaining behaviour change in our sample of obese adults. The overall HAPA model provided a satisfactory fit to the data and the introduction of worry in the HAPA model did improve the model's fit.

Reflections

CVD Risk Communication

Finding appropriate ways to communicate CVD risk is important in the prevention of disease. Although primary prevention depends on the recognition and management of risk factors, a large number of people at risk of developing CVD health-related problems are unaware of their risk. Furthermore, traditional risk formats such as the % CVD risk seem to be re-assuring to individuals (Marteau et al., 2001). For example, a low probability estimation of 5% risk of developing CVD in the next 10 years is mainly interpreted as a 95% risk of not developing CVD. However, more heart attacks and strokes affect people who have been diagnosed by the traditional % risk formats as being in the low or moderate levels of risk (5-10% CVD risk) than at the highest levels (Public Service Review). Our recruited sample had moderate levels of risk, as diagnosed by the % risk format, and was not over the 20% high CVD risk threshold (Wood et al., 2005; NICE Report, 2008). They had though at least one elevated modifiable CVD risk factor (i.e. being obese and/or smoking). The findings of our first two studies are crucial, because they showed that for a sub-sample of this population, those at higher risk, the Heart-Age risk message was more influential in creating appropriate risk perceptions than a traditional risk format (% CVD risk) or a control group. Also, younger individuals at higher actual CVD risk found the Heart-Age to be more emotionally impactful.

The Heart-Age risk message does not communicate the actual CVD risk of an individual but instead portrays a risk analogy relative to other people belonging to the
In both of our proof of principle studies (Chapter 2, 3) the Heart-Age risk message was not more effective in increasing the intention to improve the targeted health behaviours than the % CVD risk message or a control group. These non-significant differences in intentions between groups could be due to a number of reasons. First, the effectiveness of risk communication may depend to some extent on the behaviour we are trying to change. The CVD risk communication may tap nicely on the intention to stop smoking but does not exert such a big influence on the intention to change dietary behaviours. The increase in the intention to stop smoking in the first study (Chapter 2) was close to reaching significance (p=0.09) with 52% of participants receiving the % CVD risk score reporting an intention to stop smoking and 62% of participants receiving the Heart-Age risk score reporting an intention to quit. Second, our study was not powered to detect significant changes in the intention to stop smoking in this subgroup (n=165) of our main sample (i.e. smokers) and further studies are needed. Third, risk perceptions may be insufficient on their own to change people’s intentions (Schwarzer, 2008). They rather set the stage for the person to think about the positive and negative consequences of performing certain behaviour (outcome expectancies).

Since risk perceptions may not be sufficient for increasing the intention to change, action and response self-efficacy (Witte, 2000) are constructs that warrant investigation. Action self-efficacy refers to ones confidence in their ability to carry out
a specific behaviour. Response self-efficacy refers to how effective the recommended action is believed to be. For example, if an individual believes that changing their dietary patterns will not change their CVD risk (low response self-efficacy) then they will be less motivated to change.

**Planning**

We conducted two proof of principle studies on the use of web-based planning also known as implementation intentions (Chapter 3 & 4). These two terms have been used interchangeably in the literature, but for the purpose of this discussion we will use the term planning. Participants were asked to formulate plans and their effects were tested over a short period of time. This is a limitation of our studies, since we cannot determine the long-term effectiveness of these plans. However, our studies were investigatory in nature and one of the few (Budden et al., 2007; Osch et al., 2010) that tested whether individuals can form plans online and the effects of these web-based plans on individuals’ saturated fat intake. To the best of our knowledge these were also the first studies utilising a web-based volitional help sheet to link a set of specified situations and solutions. Similar positive results of using a volitional help sheet off-line have been reported in previous face to face studies in the area of stopping smoking, increasing physical activity and stopping binge drinking (Armitage, 2008, Armitage & Arden, 2011, Arden & Armitage, 2012).

In our studies web-based plans were effective in changing self-perceived saturated fat intake (TIS), but not % saturated fat based on the FFQ. The fact that web-based planning was not effective in both outcome measures may be due to a number of reasons. First, FFQs were initially designed to estimate individual dietary intake and might not be sensitive enough to detect small changes in dietary intake (Cade et al., 2004). In contrast, self-reported measures such as the TIS have been specifically designed as simple scales to assess behaviour change (Armitage 2004; Chapman et al., 2008). Second, the low and negative correlations between these two measures both at baseline and at the end of the study (week1 r=-0.32; week5=-0.29) indicate that they are measuring a different construct. It may also be that participants in our sample were mostly eating smaller portion sizes of high saturated fat foods. The present FFQ did not account for individual variations in portion sizes, but instead assumed the average portion of the UK population, which might differ from the portion consumed by
overweight and obese individuals. For example, in the study described in Chapter 4 we found a significant reduction in the portion sizes of high fat foods in the combined planning and SMS reminders condition in comparison to the control group.

Investigating the type of formulated plans is also of great interest. In the literature a distinction is made between action and coping plans. Action planning includes specific parameters of the situation (i.e. when, where), while coping planning refers to the anticipation of barriers and the generation of alternative behaviours to overcome them. In our studies, mediation analysis showed that participants in the intervention groups were more likely than participants in the control group to report using coping plans. This in turn led to greater saturated fat reductions (Chapter 4). However, participants in both studies created mostly action plans instead of coping plans (Chapter 3 & 4). Other research has found that action plans are more effective in the beginning stages of change, whereas coping plans are more instrumental at later stages in the behaviour change process (Sniehotta et al., 2005; 2006). Future studies are needed to explore the role of action and coping plans at the different stages of the behaviour change process.

Furthermore, a distinction is made between two components of effective goal pursuit; namely self-maintenance and goal maintenance (Kulh and Fuhrmann, 1998). Our planning interventions tapped nicely on the goal maintenance aspect by enhancing the accessibility of the situational cue and creating an association between the cue and a specific response. The present exploratory studies (Chapter 3 and 4) have not though tapped on the self-maintenance aspect; that is constructs that help people maintain an awareness of themselves, their values or their skills. Such constructs include boosting an individual’s self-efficacy and sense of autonomy (Luszczynska et al., 2009; Koestner et al., 2006; Koestner et al., 2002). For example, Koestner et al (2006) combined planning with either self-efficacy boosters or autonomy supportive conditions when creating plans and found that both conditions were superior to a control group at 1 month and 5 month follow-up respectively. Luszczynska et al (2009) further found that self-efficacy beliefs moderated the effects of an intervention focusing on action and coping plans such that respondents with high self-efficacy beliefs improved their diet and exercise more than those with lower self-efficacy beliefs. It is recommended that future research combines planning with sessions that boost self-efficacy.
Creating conditions that foster autonomy is of foremost importance. In our web-based planning tool, we let people freely choose their most relevant situations and solutions from a predefined list with the aim of promoting their sense of autonomy. Our list of situation-solutions was based on previous research (Prochaska, 1979; Rossi et al., 2001; Velicer et al., 1990). This list may have been incomplete; missing out on situation-solution pairs relevant for this specific population. Future studies are needed to compare conditions of complete autonomy (e.g. through free text writing) versus conditions in which situation-solution pairs are developed through appropriate cues. A disadvantage of the former condition may be that participants find it difficult to create complete and precise plans when given complete autonomy (De Vet et al., 2011; 2011, van Osch et al., 2010). For example, a field study on obesity prevention found that over 30% of respondents did not form sufficiently precise plans (De Vet et al., 2011).

In Chapter 4, combining planning and SMS reminders of people’s plans, resulted in reductions in perceived portion sizes and perceived saturated fat intake. Our study was one of the first ones to use simple reminders of people’s plans on a random sequence (three times per week) and to monitor the effects of combining plans and SMS reminders on people’s saturated fat intake and portion sizes. To date, health behaviour research on the use of SMS reminders is at a very preliminary stage and does not come with clear guidelines on the number of SMS reminders per day/week or on the content of these messages. A previous study (Prestwich et al., 2010) found that sending SMS reminders of individuals’ goals (e.g. be healthier), but not plans (e.g. reduce saturated fat intake), activated other health behaviours (e.g. dietary restriction) leading to other relevant health outcomes (e.g. weight loss). In our study, we found no effect of the combination of planning and SMS reminders on other health related areas such as weight loss or physical activity. We did not though provide SMS reminders of participants’ goals. Our SMS reminders were based on individuals’ plans. Future studies should examine more systematically the effectiveness of sending SMS reminders of individuals’ goals, action plans and coping plans (Sniehotta et al., 2005; 2006).

Studies on planning and other web-based tools are increasing rapidly with some studies focusing on the users’ experience (Brug et al, 1999; Oenema et al, 2005). In our study, we have asked participants’ to respond on how interesting, personally relevant and enjoyable they found the information, how credible and trustworthy the source
was and their levels of worry. We found that participants allocated to the Heart-Age risk message conditions were more worried than those who did not receive this information (Chapter 3) and that participants who received the planning interventions were less likely to be worried than those allocated to the control group (Chapter 4). Also, individuals in the combined Heart-Age and Planning condition spent more time on the web-site and found the intervention to be less interesting than those receiving just the Heart-Age risk message. Though this last finding appears odd to begin with, it indicates that web-based interactions that take too long are not always effective. In contrast, it may create conditions of cognitive over-load (Dewitte et al, 2005; Ward et al, 2000) and this needs to be further tested.

Although the above data can be quite informative, it does not tell us much about the friendliness of the website also known as ‘usability’. Broadly speaking user friendliness is determined by whether users are able to find what they are looking for, the degree to which they can successfully complete tasks online, the speed and ease with which they are completing these tasks and their levels of satisfaction (Stoddard et al., 2006). We assessed user friendliness by testing whether people were able to complete the number of plans set in our instructions. In our studies we asked participants to formulate at least 3 plans. In the study described in Chapter 3 all of the participants were able to formulate an average of 3.9 online plans. In the next study (Chapter 4) all participants were able to formulate their 3 plans online with 85% completing 4 situation-solution pairs. It would have been informative if we had qualitative data on how individuals engaged with the planning tool while trying to formulate their plans.

**Mechanisms of Behaviour Change**

Moderation, mediation as well as moderated mediation analyses are helpful in understanding the mechanisms involved in behaviour change and how this may differ in different sub-groups of the population. We were interested in investigating the mediating mechanisms in the relationship between risk perceptions and intentions and the translation of planning into behaviour. We further tested a number of
moderators (i.e. age, intentions, and self-efficacy) of the relationship between planning and behaviour.

In a recent meta-analysis, it was argued that risk perceptions are more likely to have an effect on behaviours that are easier to perform (i.e. sun screen protection) than on more complex behaviours (e.g. healthy eating) that are more susceptible to external influences (Brewer et al., 2007). Our mediation analysis aimed to shed light on some mechanisms by which risk perceptions may be translated into the intention to change these more complex behaviours. We found that feelings of worry and participants’ personal judgements acted as mediators in the relationship between risk perceptions and intentions to change physical activity and diet. That is individuals, who felt worried and perceived the information positively (i.e. credible, interesting, reliable), were more likely to develop an intention to change their behaviour. These findings are in line with affect as feeling heuristic and affect as information perspective and propose a complementary role of an individual’s affective and their cognitive evaluations of the CVD risk information (Schwarz & Clore, 2003; Loewenstein et al., 2001).

In addition, the mediating effect of worry was larger than the mediating effect of intervention judgements in the relationship between risk perceptions and intentions in relation to all health behaviours (i.e. stopping smoking, eating more healthily and being more physically active) (Chapter 6). This could be because feelings may work at a sub-conscious level before we cognitively process the information. Based on the affect heuristic, feelings go through an experiential route of processing, which is based on intuition and instinct and acts in a faster way than the rational system of information processing (Slovic et al., 2005). In other words, we may first feel and then process the information in a logical manner. Other theories further suggest that emotional or affective responses can directly influence an individual’s judgements about the interpretation, the meaning and significance they give to the received information (Lazarus, 1993, Clore, Schwarz, & Conway., 1990). Affect is therefore essential to rational action (Damasio, 1994).

The role of feelings of worry was especially evident in the relationship between risk perceptions and intention to stop smoking. Feelings of worry (but not intervention judgements) almost fully mediated the relationship between risk perceptions and intention to stop smoking. Similar findings on the role of worry on behaviour in the
arena of smoking cessation have been reported in previous research on graphic cigarette warning labels (Hammond et al., 2004). These findings suggest that affective evaluations can sometimes diverge from cognitive ones (e.g. intervention judgements) demonstrating a direct effect on behaviour (Lowenstein et al., 2001; Slovic et al., 2005). This may be due to factors such as the immediacy of the perceived risk or the vividness with which health outcomes are represented mentally. For example, smokers presented with their personal CVD risk possibly may have created strong, vivid mental images closely linked to emotions of worry and wake-up call. This may trigger a need to protect their heart in turn leading to an intention to stop smoking.

However, emotionally impactful messages can lead to either negative or positive behavioural responses. Affective responses can have a positive impact prompting the individual to be more vigilant (Bagozzi et al., 1999). If the emotional reactions are too strong, the individual may experience denial, downplay the event and therefore behaviour change may be discouraged (Carver, 1998; Ruiter et al., 2001). At exaggerated levels, worry is also an important feature of generalised anxiety disorder (Borkovec et al., 2004). In the present studies, affective responses comprised of both feelings of worry about the information received and also feelings of vigilance by perceiving the information as a wake-up call. They were of moderate intensity (mean=4.4 on a 7 point Likert scale) and therefore did not worry the participants unnecessarily or hampered the risk information processing.

A possible explanation of these results that warrants further investigation is linked to mood-related research. In daily life, we feel good when we obtain positive outcomes or are not threatened by negative ones (Schwarz & Clore, 2003). This positive mood state fosters top-down processing that relies more on general knowledge, higher playfulness and creativity, creative problem solving and more efficient decision making (Fredrickson, 2001; Isen et al., 1999). Thus, it is possible that the CVD risk messages eliciting moderate affective responses of worry and vigilance were associated with a more positive mood state leading to a greater intention to change behaviour. Of course, these findings warrant further investigation in different target populations and health behaviours.

Another finding of the present thesis is that risk information was more emotionally impactful for younger individuals (30-45 years) (Chapter 2). These individuals
perceived the Heart-Age risk information as more worrying and a wake-up call than their older counterparts. It is possible that this is one of the few times these individuals were prompted to think more carefully about their future heart-health. On the other hand, older individuals are more likely to have been exposed to this information before by their health care professionals and in turn may be less affected by it.

In our study, younger individuals (i.e. those in their late thirties) were also more likely than their older counterparts to benefit from planning to turn good intentions into saturated fat intake reductions (Chapter 5). This suggests a related need in this population to receive some guidance and help in planning a behaviour change. The results from previous studies are mixed. In favour of our results, in a study by Scholz et al (2007) older adults showed high initial levels of coping plans before the intervention, while at the end of the study younger individuals were the ones with the highest increase in coping plans in relation to their exercise behaviour. Some other studies on physical activity behaviour have found greater effects of high levels of planning for older or middle aged people than for younger people (Reuter et al., 2009; Renner et al., 2007). It is true that under the right circumstances planning can act as a mnemonic for older people to overcome age-related cognitive problems (Reuter et al., 2009). Since both younger and older people may benefit from planning there is need for more sensitive planning tools designed to tackle the needs of both older and younger individuals.

We further tested the effects of other moderators –namely self-efficacy and intentions- in the relationship between planning and saturated fat intake. We found that high intenders were more likely to create plans and reduce their saturated fat intake. Also, people high in self-efficacy were most likely to benefit from planning in changing their behaviour. Individuals with low levels of self-efficacy benefited more from less planning or in other words from less pressure to plan to change their behaviour. In this latter group, boosting their self-efficacy might be a first necessary step before attempting to change their behaviour. However, one needs to also consider the complexity of the behaviour under study. For example, Wiedemann et al (2009) found that intentions had to exceed a higher threshold in physical activity than in inter-dental hygiene.

**Theoretical Framework**
The present thesis is based on a specific theoretical framework (the Health Action Process Approach). Brug et al (2005) suggested that ‘theory based interventions are the only acceptable way to proceed in the promotion of healthy diet and physical activity habits’. There are various models focusing on explaining behaviour such as the Health Belief Model (Janz, 1984), the Transtheoretical model (Prochaska & DiClement, 1984) and the Theory of Planned Behaviour (Ajzen & Becker, 1985). The Health Action Process Approach model has the benefit of trying to explain the processes that take place on both the motivational and also the volitional phase of behaviour change. Based on the HAPA model we conducted three proof of principle studies, in which we tried to tackle the motivational, the volitional phase, and a combination of the motivational and the volitional aspects of the HAPA model.

Although theoretical models provide information on the different determinants of behaviour (e.g. risk perceptions, planning) and ways to measure them, they do not come with specific instructions on how to change these determinants. The HAPA model has been evaluated in a number of longitudinal studies with the aim of testing the theory’s constructs, but without intervening (Scholz et al., 2005; Luszczynska & Schwarzer, 2003; Schwarzer et al., 2007). More intervention studies are needed on how to change the hypothesised determinants with clear descriptions of the intervention tools. In our study for example, we created a planning tool to improve the determinant ‘planning’ within the HAPA model.

It is also necessary to use more standardised definitions of the different constructs in theoretical models. For example, the terms action, coping plans and implementation intentions have been used almost inter-changeably in the literature. Differences exist though between the three constructs. In a recent taxonomy written by Abraham & Michie (2008) an attempt has been made to create standardised definitions and to categorise different cognitive and behaviour techniques in a systematic manner to facilitate successful replication and comparison of studies.

Furthermore, for successful behaviour change multi-component interventions - in which researchers intervene on several determinants – are most effective (Webb et al; 2010). However, in these multi-component intervention studies, it is difficult to determine which strategies or combination of them worked best. It is therefore crucial that we also conduct small scale proof-of-principle studies such as ours. Our results
can be informative, since the effectiveness of separate strategies can be disentangled. For example, in our present small scale experimental studies we found that the combination of a risk communication message and the planning tool did not seem to work well together, while each worked well independently. Our results also showed that planning worked well in combination with SMS reminders in reducing portion sizes.

We also tried to test whether the overall HAPA model fitted the data well. We used structural equation modeling (Hoyle, 1995), which is an advanced statistical analysis. Structural equation modeling compared with simple regression analysis has the advantage of dealing with the unreliability in measures by conducting confirmatory factor analysis. Another advantage is that it can deal with more complex designs (e.g. multiple mediators). In the present analysis we found the existence of a number of multiple mediating mechanisms. For example, action self-efficacy was linked to intentions, which in turn was linked to saturated fat intake via planning. Other important findings included the fact that maintenance self-efficacy did not affect saturated fat intake directly, as one of the routes suggested by the HAPA model, but via planning. We tried to expand the model by including feelings of worry as a mediator in the relationship between risk perceptions and intentions. Our hypothesis was confirmed. The inclusion of worry improved the model fit, suggesting the need for further investigation of this construct within the HAPA model.

**Measures**

Two different self-report measures of saturated fat intake were used in this thesis (i.e. TIS and FFQ). The use of self-reports to measure saturated fat intake is a methodological limitation of our studies. Although the FFQ is a validated instrument previously administered in the UK population and the TIS items had good internal reliability scores, collection of more objective data would be preferable. Within the present online context, it was not possible to collect objective measures of participants’ consumption of saturated fat (e.g. receipts of foods bought at the supermarket). Our self-report measures are further limited by the complexity of the behaviour we tried to measure. Changing fat consumption is complicated since there are different types of fats (i.e. saturated, unsaturated, monounsaturated, trans fats) with different health
effects. So we may need to educate individuals on the different types of fats first before measuring.

The FFQ used in our study (Margetts et al, 1989) focused on the frequency of consumption of different foods, not portion sizes. A questionnaire including figures with examples of different portion sizes of foods would have been preferable. However, developing these types of questionnaires for online use is time consuming. Alternatively, we decided to include 11 items with the highest saturated fat loadings and assessed individuals’ perceived changes in portion sizes (Chapter 4). The importance of assessing portion sizes was confirmed as participants in the combined conditions (planning and SMS reminders) reported a greater reduction in their portion sizes than the control group.

Weight status was also assessed by self-report (self-reported weight and height) and this is another limitation of our study. Waist circumference, a rather useful measure of obesity and an important criterion of health risk, was not measured. Recent guidance from the UK National Institute of Health and Clinical Excellence states that assessment of the health risks associated with overweight and obesity should be based on both BMI and waist circumference in adults with a BMI less than 35 (National Health Survey, 2008). A BMI of over 35 is associated with increased health risks regardless of waist circumference. Future researchers are recommended to take into account waist circumference in addition to weight status.

**Population**

We focused on a rather broad age range (30-60 years) since we believed this age group is more likely to think about their health than their younger counterparts. Moreover, in people younger than 30 years old their Heart-Age risk scores would have been very close to their actual age, since age is one of the most important CVD risk factors influencing the Heart-Age score. This limits the usability of the Heart-Age risk score for younger people. Individuals in the age range of 30-60 years were further chosen because, though numerically a greater number of older people seem to be affected by CVD mortality, recent trends in age-specific rates raise the alarm for younger individuals. For example, for younger men between the ages 35-55 years the Coronary Heart Disease (CHD) mortality rates in 2002 increased for the first time in over two
decades (British Heart Foundation, 2008). Also between the ages of 45-64 years, 1 in 9 women have some form of cardiovascular disease (Rosenfeld, 1992).

We further focused on overweight and obese individuals, since the proportion of people categorised as obese has increased from 13% of men in 1993 to 24% in 2008 and from 16% of women in 1993 to 25% in 2008 (NHS Health Survey for England, 2008). Overweight and obesity is further associated with the morbidity and mortality of many health conditions, such as CHD, Type 2 diabetes, gall bladder disease, ischaemic stroke, osteoporosis, sleep apnoea and some types of cancers (WHO 2000). In a review by the National Health Foundation in Australia good evidence was reported of an association between overweight and obesity and CVD incidence in young to middle-aged adults (Australian Institute of Health and Welfare, 2004).

A limitation of our studies is related to the fact that we recruited a convenience sample, who responded to email invites by an online recruitment agency. As a result, they were self-selected and more likely to show higher levels of motivation than the general overweight and obese population. This limits the generalisability of our findings. Also, we carried out recruitment online and as a result our population may differ from overweight and obese individuals found in a clinical setting.

**Design**

We used a randomised controlled trial (RCT) design in all three of our proof of principle studies (Chapter 2, 3 & 4). Participants were randomly allocated to the conditions using a computer generated list of random numbers. This is a strong aspect of our design, since RCTs are generally acknowledged to provide the most reliable estimates of intervention effects.

Although we have used a rigorous design, our studies have been constrained by other methodological limitations. Health behaviour change interventions often comprise multiple techniques and these techniques are compared disproportionately between experimental conditions (Michie et al., 2008). For example, in one of our studies planning SMS reminders was compared against a planning and a control group.
Without the inclusion of a condition that received SMS text messages only, it is not possible to determine the components of the intervention that caused the significant change in saturated fat intake changes. This is a common problem with multi-component interventions. Due to the limited number of experimental conditions, it is not possible to determine the effectiveness of the separate components.

When designing our studies we further deliberated on what comprises an appropriate control group. Our first study on risk communication (Chapter 2) has the limitation of comparing between a Heart-Age and % CVD risk message and therefore does not use a ‘no treatment’ control group. An appropriate control group is regarded a group a) receiving usual care (Vale et al., 2003; Sheridan et al., 2006), b) receiving a leaflet with generic information on CVD risk factors (Lipkus & Prokhorov, 2007) or c) filling out questionnaires only. In our study, the group who received the % CVD risk message could be regarded as receiving usual care as this is currently one of the most commonly used CVD risk formats.

In the studies described in Chapter 3 and 4, we used a control group that received educational information on saturated fat intake and also filled out a number of questionnaires at pre-and post-test. This may have led to reductions in saturated fat intake in the control group limiting the contrast with the intervention group. A similar effect has been observed in previous studies (van Sluijs et al., 2006; Godin et al., 2008). The optimal design to test for measurement effects would have been the Solomon four-group design (van Sluijs et al., 2006). That is using 1) a pre-test and post-test control group, 2) just a post-test control group, 3) a pre-test and post-test intervention group and 4) just a post-test intervention group.

**Future Research**

Web-based plans proved to be a promising self-regulatory technique (Soureti et al., 2011a Chapter 3; Soureti et al., 2011b Chapter 4). They were effective in changing self-perceived saturated fat intake and portion sizes, but not % saturated fat based on the FFQ. The fact that web-based planning was not effective in changing all of our outcome measures limits the generalisability of our results. It is clear that in relation to saturated fat intake a number of alternative and more objective assessment methods needs to be considered. It is recommended that in future research, measures
Considering portion sizes are included as people may be likely to change the frequency but most importantly the portion size of the foods they are consuming.

Changing fat consumption is complicated by the fact that there are different types of fats (i.e. saturated, unsaturated, monounsaturated, trans fats) with different health effects. It may be the case that for more complex behaviours several actions need to be performed before one can satisfactorily carry out the target behaviour (de Vet et al., 2011). Studies on plans targeting saturated fat reductions could benefit by taking a closer look at a number of separate behaviours that lead to reductions in saturated fat. This can include the substitution of high with low fat alternatives, the elimination of high fat foods from ones diet or the reduction of portion sizes. The question arises for future studies whether a single goal formation (e.g. reduce saturated fat intake) is yet effective or whether a number of different plans fulfilling the same goal is needed. It is further worth considering different ways of combining motivational strategies (i.e. risk communication) with volitional strategies (i.e. plans). In our study, risk communication and plans worked well independently on changing risk perceptions and saturated fat intake, respectively, but failed to produce similar effects when used collaboratively. Also, individuals in the combined condition spent more time interacting with the system and found the information less interesting. So the question posed for future researchers is how do we best combine these strategies in order to successfully change behaviour?

When individuals create specific plans they link a specific tempting situation (i.e. cue) with a specific response. What would happen if these plans were offered just before or after the peak of a difficult situation? Advice offered right at these moments is likely to reduce an individual’s relapse proneness or perhaps act therapeutically after a lapse. Shiffman et al (1997) found that lapses resulted in increased negative affect and decreased self-efficacy. During these moments of negative affect and reduced self-efficacy individuals can be re-assured and can be prompted to get back on track. Future research is needed on the use of digital technologies and mobiles to tackle these moments of increased lapse proneness and increase individual’s eagerness to get back on track and deal with their cravings. For example, individuals may use mobile applications at the time when a craving is experienced to log in and create a coping plan to deal with the craving right at the time it is occurring.
In our intervention we targeted individual determinants of behaviour change using a number of motivational and self-regulatory strategies. However, many health professionals have argued that in order to reduce opportunities for unhealthy behaviours we also need to target environmental changes (Ball et al., 2006). Environment is defined as everything and anything outside the person, such as the physical and social neighbourhood, and the workplace or school. A systematic review identified a number of environmental and societal influences acting on cardiovascular risk behaviours such as accessibility of foods, the proximity of parks and variety of fast food outlets (Chow et al., 2009). Future studies thus need to use a multi-level approach acting on different levels (i.e. individual, community and environmental).

The Internet has become a very popular medium for the delivery of health promoting interventions in health behaviours such as weight management (Tate et al., 2001, Ware et al., 2008), physical activity and exercise (McKay et al., 2001, Budden et al., 2007). It is important to focus attention not only on intervention efficacy but also on the usability of web-based interventions. Usability is a measure of quality of the user’s experience. It is determined by how easy users are able to find what they are looking for on a site, the degree and speed to which the users can successfully complete tasks online, their levels of satisfaction, perceived credibility of the site, and by how forgiving a system is to user blunders (Palmer, 2002; Stoddard et al., 2006). Broadly speaking it is regarded as standard practice to complete usability tests in online systems (Nielsen, 2000). A number of studies are further now conducted seeking user and expert opinions to identify those determinants that hinder or help exposure to Internet-delivered interventions (Brouwer et al., 2008, Schneider et al., 2012). It would be really informative for the development of future interventions if more qualitative data are gathered on how participants interact with automated digital tools (e.g. planning tool) and any difficulties they encounter in this process (Stoddard et al., 2006).

Furthermore, online lab-based experiments differ in their navigation from real life websites. In a lab-based setting, participants normally follow a pre-determined sequence (e.g. a page has to be completed before the user goes to the next). To some extent this resembles the idea of tunnelling, in which the individual is pushed through various tasks without any freedom on how to navigate a site. In real life the individual can bounce forwards and backwards on web-pages, relapse and act in a very
idiosyncratic manner. Future studies need to take into consideration such conditions and compare between sites with a pre or no pre-determined structure.

In the future, we will need to determine the extent of automation in web-based applications. Is human contact totally unnecessary? Could we help people become effective planners without counsellors intervening with their preparation? Face to face counselling can have indeed positive outcomes but is expensive and often not feasible in large scale projects (de Vet., 2007). Furthermore, in face to face studies, the presence of an experimenter to explain instructions and guide individuals in completing tasks is quite beneficial. For example, plans that were administered with an interviewer out-performed self-administered plans (Ziegelmann et al., 2006; Luszcynska et al., 2007). In a systematic review of online interventions, it was further found that peer and counsellor support resulted in longer website visits and that other strategies such as the use of email reminders and phone contacts resulted in more log-ins (Brouwer et al., 2011). Though these findings do not necessarily mean better health behaviour outcomes, there is currently growing evidence to show that repeated visits lead to better and more sustainable behaviour changes (Vandelanotte et al., 2007; Lenert et al., 2003; Watland et al., 2004). Future studies need to establish the conditions in which face to face counselling is necessary and the extent of combining different types of off and online support that can lead to an increase in repeated log ins, longer online visits and better health outcomes.

With regards to the theoretical model, we found that the Health Action Process Approach (HAPA) theory provided a good fit to the data (Chapter 7). However, our findings have been limited by our sample (i.e. British, obese individuals) and further testing is needed across a number of different cultures and health behaviours. Also maintenance self-efficacy, as predicted by the HAPA model, has a direct effect on behaviour and an indirect to behaviour via planning. In our model testing only the indirect link was supported. This means that individuals who showed more confidence in their ability to maintain their saturated fat intake were more likely to use plans and therefore reduced their saturated fat consumption. The mediating effect of worry was tested and confirmed as an additional promising construct helping in the translation of risk perceptions into intention within the Health Action Process Approach model. Further research is needed investigating the indirect and direct effects of maintenance
self-efficacy on behaviour and the indirect effects of affective variables such as worry on the risk perception - intention relationship.

We further found a number of moderating variables (e.g. age, self-efficacy, intentions) explaining the translation of planning into saturated fat intake reductions within the HAPA model. Though younger individuals reported greater benefits from planning in helping them reduce their saturated fat intake, under the right circumstances planning could be of value for older adults as well. It could enact as a mnemonic to overcome age-related cognitive problems and make successful health behaviour changes. Future research needs to carefully design web-based planning instruments that are tailored to the population they are targeting.

Practical Implications

The practical implications offered in this section apply particularly to individuals at risk of developing CVD (i.e. overweight, obese). We offer the idea of a ‘behaviour change toolbox’, similarly to a first aid toolkit, which researchers, clinicians and health promoters can use when trying to increase individuals’ intentions to change their behaviour. This thesis offers some preliminary suggestions of promising techniques, tested in the short-term, that may be incorporated in this behaviour change toolbox.

In relation to the risk communication studies, it seems justifiable to use both % CVD risk and Heart-Age risk formats, though the Heart-Age risk message created more appropriate risk perceptions for those individuals at higher levels of CVD risk and was also more emotionally impactful for younger individuals at higher levels of CVD risk. For these subgroups, the Heart-Age could be a particularly helpful decision making tool in the interactions that physicians have with their patients. Patients, who are at higher actual risk and informed about their CVD risk may be more likely to take up the recommendations offered by their physicians. This may save valuable time from consultations.

Our findings confirm previous studies showing that CVD risk communication alone does not lead to behaviour change. Creating accurate risk perceptions is only one part of the decision making process. The question arises as to how we can use these risk analogies in a manner that is effective to motivate people to change. Additional
constructs not part of the HAPA model such as worry and intervention judgements can also be instrumental in motivating individuals to change. In specific, we found that moderate levels of worry coupled with feelings of vigilance and positive intervention judgements had the potential of turning risk perceptions into an intention to change behaviour. The indirect effects of the affective variables were greater than the indirect effects of personal judgements. This is reasonable since intuition, instinct and gut feelings existed well before there was risk assessment, probability judgements and decision analysis. We should therefore not assume that decisions are always made on a rational basis. In the future, it is recommended that health promotion campaigners consider the role of affect and personal judgements of an intervention's content as mediating mechanisms helping in the translation of risk perceptions into an intention to eat healthier, stop smoking and do more physical activity.

Using new technologies such as the Internet have promising possibilities for the delivery of behaviour change interventions. They give health professionals the opportunity to provide interactive, individualized interventions to large numbers of people. In specific, use of our web-based planning tool provided promising results to change dietary behaviour in the short-term and is therefore recommended as one of the volitional strategies to be incorporated in this ‘behaviour change toolbox’. Our web-based planning tool was one of the first ones to test if-then plans in the format of an interactive online volitional help sheet. However, breaking down difficult behaviours such as saturated fat intake into simpler steps may be another possible recommendation. Also, the effects of coping plans at later stages of change need to be considered. Once a plan has been formulated and the person has acted, they may be at a greater need of coping plans to maintain their behaviour and to deal with the encountered difficulties.

Use of SMS reminders successfully boosted the effects of the web-based plans in the short-term, particularly in relation to portion sizes of high saturated fat foods. Similar effects of the SMS reminders have been reported before in the arena of exercise and brisk walking (Prestwich et al., 2008; 2010). If reminders are set at ecologically valid times (e.g. when an individual is experiencing a craving to eat a high fat food) then their effects may be maximised. They will be able to increase the frequency and in turn the automaticity of the new behaviour leading gradually to the development of a new habit (Verplanken, 2005). Health promotion campaigners and designers of web-based
health systems need to consider the use of such technologies in boosting the effects of their systems.

Developing theory based interventions is crucial when designing interventions. From a mechanistic perspective, we found that the HAPA model provided a good fit for the data and it is therefore recommended as a useful framework when considering saturated fat intake in obese individuals (Chapter 7). The present findings provide also some further guidance on ways to expand the model (i.e. inclusion of worry) and on the role of planning in bridging the intention-behaviour gap. Since different subgroups may need different intervention approaches, we also specified for whom planning and risk communication may be more effective. In specific, we found that individuals who have high self-efficacy and intention levels may benefit more from web-based planning to reduce their saturated fat intake. Age was another important moderating variable with younger overweight and obese individuals in their late thirties or early forties being more likely than their older counterparts to benefit from web-based planning to reduce their saturated fat intake. This is an interesting target group at high risk of developing CVD, leading hectic lifestyles and in need of guidance on how to get started.

Conclusion

In summary, we conducted three proof of principle studies testing the HAPA model in dietary behaviour change among overweight and obese adults. The target behaviour was saturated fat intake, a complex behaviour to change. We found the Heart-Age risk communication tool to be superior to the frequently used % CVD risk message regarding communicating risk in obese adults at higher levels of risk and it is therefore recommended for use in this group. We further found that our web-based planning helped in reducing self-perceived saturated fat intake and led to greater reductions in portion size in the short-term when combined with SMS reminders. More efforts are though needed to identify the best conditions for combining motivational techniques (e.g. Heart-Age) with volitional techniques (e.g. planning tool) and to investigate the effects of these techniques in the long-term, within a wider variety of populations.

From a mechanistic perspective, we found that the HAPA model provided a good fit for the data and it appears as a useful framework when considering saturated fat intake
in obese individuals. Participants’ judgment of the intervention and especially affective mechanisms such as worry were identified as important working mechanisms in the translation of risk perceptions into intentions to change. We further specified subgroups of individuals (younger individuals with high self-efficacy and high levels of intentions), who were more likely to benefit from planning to reduce their saturated fat consumption. We suggested the initiation of a ‘behaviour change toolbox’, similar to a medical first aid toolkit, in which a number of these promising motivational and volitional techniques are put together, their ways of working are specified so that researchers can further investigate them and find best ways of combining them.