PATTERNS OF EATING AND EXERCISE THAT REDUCE WEIGHT

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A Thesis submitted to
the University of Birmingham
for the degree of
DOCTOR OF PHILOSOPHY

School of Psychology
University of Birmingham
July 2012

SUMMARY

Gaps in research on reduction of obesity (Chapter 1) can be filled by experiments on effects on weight of changing the frequencies of habits of healthy eating and exercise (Chapter 2). This Thesis shows that changes in weight and customary habits can be tracked reliably. People's descriptions of meals as healthy were consistent with national guidelines (Chapter 3). Participants agreed on which of such freely worded accounts of eating occasions referred to the same habit (Chapter 4). The frequency of a habit was calculated from recalled date and time of its most recent occasions: these timings were accurately recalled over two days (Chapter 5) although precision decreased after a week (Chapter 6). There was no evidence that records of weights were biased by expectations of weight loss (Chapter 7). Data from small samples indicated weight was reduced over 2-3 weeks by less frequent high-fat meals and calories between meals but not by more frequent vigorous exercise (Chapters 8 and 9). Habit frequency changes sometimes reversed from a variety of causes (Chapter 10). A full-scale experiment is designed to substantiate such findings (Chapter 11). After extension to other localities, such research could be an immediate help in reducing obesity (Chapter 12).

AKNOWLEDGMENTS

I am thankful to the Mexican National Council for Science and Technology and the University of Birmingham for the scholarship to carry out the PhD course.

I appreciate the brilliant work of David Booth on training me with diligence to develop the scientific approach presented in this Thesis.

I would like to thank the supportive team advice of Arie Nouwen, Sara Beck and Chris Miall on moving the work on this Thesis forward.

I thank the support of Jackie Blissett for periodically reviewing the project progress and together with Rebecca Knibb examining the Thesis and advising to help improvements.

I appreciate the nice times with colleagues of the School of Psychology, their dedicated work is fantastic.

I am also grateful to my parents Elda and Antonio for all their amazing support over time.

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PART A

RESEARCH BACKGROUND

CHAPTER 1
GAPS IN RESEARCH ON EATING AND EXERCISE PATTERNS THAT REDUCE WEIGHT

1.1 Introduction

Eating and exercise affect weight by altering the exchange of energy between the body and its surroundings. That is, if the rate of intake of energy falls short of the rate of spending energy, then, in accord with the law of conservation of energy, there must be a decrease in the amount of energy in the body and thus in its weight. The question posed in this Thesis is how much the weight of the body is reduced when a decrease in energy intake or increase in energy expenditure results from a change in how often a customary pattern of eating or exercise is carried out.

This basic scientific knowledge is important because most people in the industrialised nations are gaining weight (Zanniotto, Wardle, Stamatakis *et al.*, 2006; McPherson, Marsh & Brown, 2007). The consequences of excessive fatness are costly to the individual and to society (Myers & Rosen, 1999; Kopelman, 2007; de Wit, Luppino, Van Straten *et al.*, 2010*)*. Yet the rise in prevalence of obesity has continued for decades without abatement (Moon, Quarendon, Barnard, 2007). Clearly therefore the research community has failed so far to find widely feasible changes in habits of eating and exercise that reduce unhealthy fatness.

This Chapter seeks gaps in existing research into long-term reduction of weight that could account for the failure to slow the rise of obesity. Chapter 2 explains what the research reported in this Thesis is intended to deliver that could start to fill such gaps.

1.2 Customary patterns of eating and exercise

For people to recognise clearly a pattern of eating or exercise prevalent in their locality, that habit needs to be described to them in words that are commonly used to identify it. There is no evidence in research on weight control about how familiar participants were with the descriptions of eating or exercise used by researchers or therapists. Reports of diet and exercise interventions for weight reduction provide only a general summary of the package of strategies for reducing weight (e.g., Tuomileto, Lindstrom, Eriksson *et al.*, 2001; Knowler, Barrett-Connor, Fowler *et al.*, 2002; Sacks, Bray, Carey *et al.*, 2009). For example, in their paper on lifestyle intervention on obesity, Wadden and collaborators (2005) reported that the prescription was a diet of 1500 kcal per day with less of 30 percent of the energy

derived from fats and a regimen of 30 minutes of exercise a day on most days of the week. Such packages are often delivered by trained practitioners in accord with guidelines based on nutritional theory. However, there is no design or record of what is actually said or shown to participants. So there is no information on what specific changes in behaviour might have changed weight.

Only a few studies purport to describe strategies or practices – that is, pieces of behaviour, rather than physical entities such as foods, nutrients or energy expenditure. However, usually the wordings were constructed by the investigators from clinical experience (French, Jeffery & Murray, 1998; Westenhoefer, von Falck, Stellfeldt & Fintelmann, 2004). If the investigators' terms were at all unclear to participants, then the responses would be indeterminate to that extent. For instance, a word may be ambiguous between distinct patterns of eating. For example, a 'snack' need not be between meals: the word can refer to a light lunch (Chamontin, Pretzer & Booth, 2003).

Only two studies have been found that derived the tested wordings from participants' descriptions of occasions of eating or exercise. Blair and colleagues (1989) elicited descriptions of healthy practices and then categorised and merged them into question items. Knauper and collaborators (2007) also studied categories from dieting practices reported by participants. In both cases, though, even these research teams combined and edited their informants' wordings.

To summarise, weight loss interventions on diet and physical activity generally do not target actual occasions of behaviour as they are commonly known to the public. Hence research is needed that identifies patterns of energy intake and expenditure in wordings that are agreed by the participants to refer to customary patterns of ingestion and movement.

1.3 Frequency

For a pattern of eating or exercise, the rate of energy exchange with the surroundings comes not from the number of calories in one occurrence but is the total result of how often such behaviour occurs. Quite apart from the gap in the literature on specifying each piece of behaviour was carried out, often no attention is paid to the validity of estimates of the frequency of each component of diet or physical activity.

The frequency of a habitual pattern can be calculated from a record of every occasion, made over a sufficiently long period to include rarer activities. However, it is impossible in principle to gather completely accurate records. The only person who can record all eating and exercise in words is the one who does it. Yet such a record is unlikely to be complete

because the effort needed to make the record is liable to reduce its realism, e.g. by omission in haste of some of the foods or drinks that were ingested, and even by changing the behaviour that is meant to be recorded. Energy intakes estimated from dietary records made for research into health are lower among obese people (Lichtman, Pisarska, Berman *et al.*, 1992). Some estimates from records are impossibly low relative to energy expenditure (Hill & Davies, 2000).

A less demanding procedure is to ask the participant to recall each occasion. However, even if memory never faded, the recall would have to extend back in time through repetitions of frequent habits to include the rarer habits. The repetitions could confuse recall. Also, recall is liable to the same under-reporting of eating (and over-reporting of exercise) as the selective recording of eating occasions or ingested foods in research known to be on health (Poppitt, Swann, Black & Prentice, 1998).

When frequencies are attended to, the usual procedure is to ask a question of the form *How often do you...?* Such direct questioning about frequency can be answered without remembering all or even any relevant past events (Tversky & Kahneman, 1973; Seldmeier & Betsch, 2002). In particular, people can minimise the effort of remembering many occasions by the use of heuristics to construct an answer - for example, from the time since a single event that has personal importance (Blair & Burton, 1987; Conrad, Brown & Cashman, 1998).

Furthermore, people are prone to overestimate frequencies of a practice that they carried out recently, or of occasions which are easily recalled or imagined (Tversky & Kahneman, 1973). If the question *How often do you...?* generates unreliable data on the frequency of a piece of behaviour, then incorrect inferences will be drawn about changes in frequency or their effects.

Hence, valid estimates of frequency need a method for recalling actual occasions, and exactly those occasions which determine how often the habit currently recurs. A way to do this will be proposed in Chapter 2 (section 2.3) and exploited in this project.

1.4 Weight

The research literature draws a distinction between reported weights and measured weights (e.g., Gorber, Tremblay, Moher & Gorber, 2007). Despite the scepticism with which reported weights are generally treated, the evidence is that measured and reported weights can agree closely (Stunkard & Albaum, 1981). However, this reliability across methods says little about validity on weight in life. Both reported and measured weights are deficient as measures of the individual's body weight that needs to be controlled if obesity is to be abated. The

relevant value is the actual reading that the person sees when standing on weighing scales in a standard state of the body in the course of daily life.

The routine measures of weight taken in clinics can be inaccurate because of poor weighing practices (Harris, Ellison, Holliday & Nickson, 1998) or even because the scales have deteriorated (McKay, Fozfar-Faroudi & Bowman, 1991; Stein, Haddock, Poston *et al.*, 2005).

Furthermore, the expert's measurements have to be done at a time of day that fits the schedules of both that investigator and the participant. The timing in the week and the frequency of repeated measurements is constrained by the mutual convenience of the institution and the individual. Hence, such weight values are not related adequately to standard conditions.

In addition, the reporting of weight, as of eating or exercise (1.3), to a health-interested expert is subject to weighed person's self-presentation biases towards the social norm of a healthy weight or a thin shape, as also may be the preparation for being weighed (Cash, Grant, Shovlin & Lewis, 1992; Vartanian, Herman & Polivy, 2004; Larsen, Ouwens, Engels *et al.*, 2008). That is, when asked “what is your weight?” people may report a lower weight than that measured on an investigator’s or clinician's scales (Gorber *et al.*, 2007).

As with *how often do you ...*? (1.3), the question *how much do you weigh?* is seldom asked with an enquiry about the date of the most recent occasion of weighing. Even without any biases, the accuracy of the answer depends on how recent the latest weighing was, whether at home or elsewhere, as well as on memory of the actual reading.

Finally, for research into the control of weight, the issue anyway is not the validity of the value for weight at a single point in time. The question is the validity of differences between weights recorded on several occasions in succession. Even if there were a bias in the recording of weight, from the person weighing or from the scales, if the bias were constant, it would not invalidate the differences in weight between successive records. Indeed, repetition itself seems likely to reduce presentation bias early in the series. Chapter 2 will therefore consider how this project may use records of values read at the time of weighing oneself, not reported weights in the usual sense of that term.

1.5 Exchange of energy between the body and the environment

It is loosely said that weight is reduced by less intake than expenditure. However, change in the amount of energy stored in the body is in fact the effect of a difference between the ongoing rates of energy intake and expenditure. That is, the number of calories that go in

or out at a point in time is not the cause or cure of a person's obesity. The key to weight gain and loss is the average amounts of energy that are taken in (as food and drink) and sent out (as heat and work) over a substantial period of time.

Edholm and collaborators (1955, 1970) showed that it may take three weeks for energy exchange to be rebalanced after a modest change in rates of input and/or output. Such change in weight is about 75% fat mass and 25% lean mass (Garrow, 1978, 1988). Unlike fat mass, lean mass makes a major contribution to energy expenditure. This is inferred from a positive correlation of lean mass with resting metabolic rate on a straight line ($r = 0.82$; Ravussin *et al.*, 1982). Garrow (1978) deduced that a reduction in rate of energy intake or an increase in rate of energy expenditure is partly compensated by the resulting loss of lean tissues and their energy output. Hence the resulting decrease in weight decelerates and comes to an end as the lower energy expenditure by less lean mass comes into balance with the decreased rate of intake or increased rate of expenditure by exercise. On this basis, persistent change in the frequency of any pattern of behaviour that changes the rate of intake or expenditure should cause a change in weight that reaches an asymptote within a few weeks.

In contrast, many people consider that any reduction of weight takes a long time. This may be because of the generally modest amounts of weight at best that are lost after many months of self-managed dietary or physical activity interventions for obesity (Tuomileto *et al.*, 2001; Knowler *et al.*, 2002; Wadden *et al*., 2005). Such weight loss, however, is usually a cumulative effect of several weight control strategies prescribed at consecutive visits to the clinic during the intervention. Yet these successive changes in eating or exercise are not measured (1.2) and so it is not known when or to what extent each strategy contributes to the loss in weight at the time, let alone later. Also, the changes in weight are reported at intervals of several months - seldom less than 6 months (Tuomileto *et al.*, 2001; Dansinger, Tatsioni, Wong *et al.*, 2007; Franz, VanWormer, Crain *et al.*, 2007). Even monthly intervals between measurements of weight could not track the progressive effect of a maintained change in behaviour on weight, reaching an asymptote within a few weeks.

Even the studies of particular patterns of behaviour for their effects on weight have used the intervals of many months between measures (Blair *et al.*, 1989; Coakley *et al*., 1997; French *et al.* 1998; Westenhoefer *et at.*, 2004). In consequence, these studies also missed the change in weight as it happened concurrently with the change in habit(s). Indeed, over such long periods, weight could have been affected by changes in several different sorts of eating and exercise. So, the association between changes in a specific habit and weight can be confounded by changes in other eating or exercise habits, even at different times within the

period between measurements. In short, it is unknown what changes in eating or exercise caused the change in weight. Chapter 2 introduces an approach that tracks habits and weight at short enough intervals to detect causal connections between them while those mechanisms are active.

1.6 Effect on weight of change in frequency of an eating or exercise pattern

The lack of any reports of the course of the change in weight resulting from a persisting change in behaviour (1.5) has a remarkable consequence: it is not known how much weight is lost or gained as a result of any particular habit becoming more or less frequent or intense. A few studies report the amount of weight change associated with a change in eating or exercise (Coakley *et al*. 1997; French *et al.* 1998; Mozzaffarian *et al.*, 2011). However, these reports were based on foods, nutrients, energy expenditure or dieting strategies selected by the research teams and measures taken at intervals of 3-4 years. So, their results do not represent customary practices (1.2) nor do they provide evidence of the impact on weight just after behaviour has changed (1.5). These and other reports give no indication of the extent of change in weight or in the behavioural pattern: they state only some parameter of association between the changes in behaviour and weight, i.e. the correlation or beta coefficient, or the odds ratio (Blair *et al.*, 1989; Coakley *et al*., 1997; Drapeau *et al.*, 2004).

Chapter 2 proposes a way to estimate how much change in weight is generally caused by a given change in the frequency of a pattern of eating or exercise.

1.7 Physiological mechanisms influencing effects of behaviour on exchange of energy

Research on weight control takes it for granted that less intake than expenditure reduces weight (e.g., Tuomileto *et al.*, 2001; Knowler *et al.*, 2002; Wadden *et al*., 2005). Nevertheless, the physiological mechanisms of such imbalance in energy flows have not been investigated while they are operative. Some theories about how particular eating and exercise patterns can alter the rate of energy intake or expenditure are presented next, in the order of the extent to which there is evidence for a role in weight control. Designs for testing hypothesis about these mechanisms are presented in Chapter 2.

1.7.1 Physiological mechanisms affecting intake of energy

1.7.1.1 Energetic efficiency of fat

Some of the energy from dietary carbohydrate or protein has to be spent building the fatty acid chains in the fat molecules (triglycerides) that are stored in the cells of adipose tissue. In contrast, dietary fat can go straight into the triglycerides for deposition. Hence, lowering the proportion of fat in the diet while increasing carbohydrate and protein by the

same number of calories should increase the rate of flow of energy from the body into the environment.

A causal connection between changes in intake of dietary fat and change in body weight is well documented. Lowering intake of fat is a principal strategy of weight reduction trials (e.g., Tuomileto *et al.*, 2001; Wadden *et al.*, 2005). A meta-analysis of reports of low-fat dietary interventions has confirmed that reduction in the proportion of energy from fat in the diet is associated with weight loss (Astrup *et al.*, 2000). Changes in frequency of practices involving dietary fat are also associated with changes in weight (French *et al.*, 1998; Westenhoefer *et al.*, 2004; Booth *et al.*, 2004).

1.7.1.2 The zero-calorie drink break

It has been proposed that the first line of defence against unhealthy gain in weight is to avoid calories in and with drinks during breaks from work (Booth, 1988; Booth *et al*., 2004). The theory is that adding more calories to a stomach that is still quite full from the previous meal does not keep hunger suppressed as well as calories taken in during or just before a meal. That is because the extra calories have little effect on the rate of emptying from the stomach when the emptying is fast from a lot in the stomach. The rate of gastric emptying controls the flow of energy substrates to the small intestine and liver, and a rapid flow is thought to have a satiating effect. Hence people get hungry as the stomach becomes nearly empty and the flow from it slows greatly. A modest amount of food at that stage restores the flow to the liver and postpones the rise in hunger. In contrast, that food at any earlier stage would make negligible difference to the rapid emptying and so be less effective at delaying emptying and postponing hunger. Hence those calories are less well compensated by a reduction in intake at the next meal (Booth, 1988).

Another way in which this mechanism could work is by increasing the temptation to keep eating between meals if the subsequent meal is expected to be later than the start of hunger. The same mechanism could make dieters who eat small meals more prone to snacks between meals.

In accord with this theory, several types of evidence indicate that reduced ingestion of calories between meals is associated with a lower weight (Coakley *et al.*, 1998; French *et al.*, 1998; Westenhoefer *et al.*, 2004; Booth *et al.*, 2004).

1.7.1.3 Including sufficient protein in meals prevents hunger before the next meal

A high proportion of protein in a meal was early discovered to delay the rise of hunger (Booth, Chase & Campbell, 1970). It has long been known that amino acids absorbed from

the digestion of protein are temporarily stored in muscles and released as alanine and glutamine as the insulin response to absorption decline. The liver uses these amino acids to produce glucose. This extra glucose should delay the rise of appetite for food as absorption of the last meal slows. Hence, high-protein meals reduce the risk of the snacking that results from hunger before a meal is due (1.7.1.2).

High protein diets have been shown in weight control trials to be more effective than high-carbohydrate, low-fat diets in reducing weight (Skov, Toubro, Ronn *et al.*, 1999; Due, Toubro, Skov & Astrup, 2004). This is possibly, in part at least, an effect of the late satiating effect of protein which translates into improved compliance with the diet.

1.7.1.4 Conditioning of satiety

Ingestion of a high concentration of readily digestible starch on an empty stomach at the start of a meal contributes to a reduced appetite on subsequent occasions for the dessert eaten 10-15 minutes later. This is the result of associative conditioning by an aversive effect of the action of hypertonic glucose on receptors in the wall of the small intestine (Booth & Davis, 1973; Booth, Lee & McAleavey, 1976). The stretch of the stomach combined with the dessert's sensed characteristics form a conditioned stimulus that inhibits eating when the combination recurs late in a subsequent meal (Booth, Mather & Fuller, 1982). In this way, starting a meal with starchy food could reduce the size of later meals that end with similar foods.

The effectiveness of conditioned satiety in weight control would depend on a number of other factors. First, the energy density of the dessert will determine whether or not the energy content of the meal is appreciably reduced. Secondly, the reduced size of one meal might provoke increased intake at the next meal or snack (and perhaps after). The question then is how complete such 'behavioural compensation' (Booth, 1972) is in terms of daily energy intake, i.e. the average rate of energy inflow. The answer is liable to depend greatly on the timings and sizes of the successive meals.

1.7.2 Physiological mechanisms of energy expenditure by movement

1.7.2.1 Walking fast

Walking is a common form of physical activity. Rapid walking uses more energy. If variations in walking speed are not well compensated by resting or eating, then increasing the speed of walking could be an option to raise the rate of energy expenditure. Daily walking is positively associated with weight loss (Westerterp, 2001; Ross, Dagnone, Jones *et al.*, 2000; Miyatake, Nishikawa, Morishita *et al.*, 2002).

1.7.2.2 Moving around rather than sitting down

A widespread pattern of behaviour that conserves energy is sitting down, for a variety of purposes. If people moved around a little whenever possible, rather than continuously sitting for a large part of the day, then this increase in energy expenditure might not be compensated by extra resting. A decrease in time sitting is associated with reduction in body fatness (Dunn, Marcus, Kampert *et al.*, 1999).

1.7.2.3 Stairs rather than lift/escalator

Climbing stairs requires more work than going down the stairs, which again costs more energy than standing still. Hence using the stairs instead of a lift or escalator is an option for extra expenditure of energy. Some research indicates that frequent use of stairs is potentially beneficial to health. For instance, an increase in ascents by stairs is associated with improvements in cardiovascular function (Sesso, Paffenbarger, Ha & Lee, 1999). Very little is known about the impact on weight of the practice of walking up or down the stairs when a lift is also available.

1.7.2.4 Housework

Cleaning rooms and other housework involves moderate or even vigorous movement that might contribute to the weekly rate of energy expenditure (Westerterp, 2001). The possible effect on weight of doing housework more often remains to be explored.

1.7.2.5 Exercise with high intensity

A possible limitation of strategies to reduce weight that demand vigorous exercise is that they are too difficult to maintain (Perri, Anton, Durnin *et al.*, 2002) and so any lost weight is regained. Some leisure practices such as swimming, gardening, ball sports, running etc. may be sustainable forms of vigorous activity. Thus their adoption or increase might contribute to an increase in the rate of energy expenditure that reduces weight for an indefinitely long period.

1.8 Persistence of change in frequency of a pattern of eating or exercise

Although weight can be reduced substantially during interventions based on a low calorie diet and an exercise regime, the weight lost is regained during the period to follow-up (Franz *et al.*, 2007; Mann, Tomiyama, Westling *et al.*, 2007). A simple explanation of this is that the changes in behaviour that reduced weight do not persist (McGuire, Wing, Klem *et al.* 1999; Heymsfield, Harp, Reitman *et al.*, 2007; Befort, Stewart, Smith *et al.*, 2009; Lapointe, Ouwens, Engels *et al.*, 2010).

A major gap in the evidence for this explanation is that changes of eating and exercise, and lapses from them, are not tracked as they occur (1.5 and 1.6). Thus, evidence is also lacking that reversal of a weight-reducing change in any specific eating or exercise habit contributed to the regain of weight.

If changes in eating or exercise are not maintained as necessary for long-term weight loss, then the key issue is why people lapse from such changes. A review of research into factors in maintenance of lost weight pointed out that studies use a wide variety of methodologies, are inconsistent in the ways of reporting findings, and can draw only limited conclusions because of large numbers of variables and the few studies that explored each variable in turn (Elfhag & Rossner, 2005).

A few studies have explored the context of occasions of lapsing, i.e. violation of a diet (Carels, Hoffman, Collins *et al.* 2001; Carels, Douglas, Cacciapaglia *et al.*, 2004; Tomiyama, Mann, Conner *et al.*, 2009). However, factors in lapsing were sought across all sorts of eating occasions. This made it impossible to investigate the specificity of a factor to a type of ingestive behaviour. Thus, the findings risk mixing up potentially different causes of lapsing for distinct patterns of eating or exercise. Furthermore the research teams composed the wordings of the factors to be investigated. There is a dearth of research into dieting and weight control where the participants have been asked to recount in their own words why they failed to keep up the changes in behaviour with which they began.

Hence a comprehensive theory has yet to be formulated about influences on lapses from changes in patterns of eating and exercise that reduce weight. In that situation, this part of the thesis now turns to the scientific literature on triggers of overeating in the hope of help in understanding why people lapse from intentional changes in eating. As outlined in Chapter 2, particular factors grounded in the best available theory can then be tested when investigating causes of reversal from a change in frequency of a customary pattern of eating, and perhaps also of exercise.

1.8.1 Breakdown of dietary restraint as a model for a lapse

Research conducted in the laboratory among people who have done some dieting has shown that they can be tricked into overeating when they are distracted by other tasks, including tasks on food that has been made available in an unlimited amount. A standard procedure is to ask the participants to evaluate the taste of icecream after consuming a milkshake. In an early experiment, the dieters ate 54% more icecream than the non-dieters (Herman & Mack, 1975).

There have been difficulties in extrapolating from the original laboratory experiments to overeating in ordinary life (Tomiyama, Moskovich, Haltom *et al.*, 2009). Nevertheless the laboratory findings illustrate the idea that there can be factors in the personal and environmental context that are liable to cause extra eating, even (or especially) in people who have tried to adopt widely used strategies for controlling weight.

1.8.2 Cognitive factors in lapses

1.8.2.1 Shift from the mind-set of dieting

One early explanation why dieters overate was the 'what the hell' effect (Herman & Mack, 1975): when dieters perceive that they have broken their diet, they have no more reason not to enjoy the icecream. Stroebe *et al.* (2008) reported that the dieting mind-set can be disrupted by thoughts of the enjoyment of eating. Complementing studies show that strengthening the existing determination to diet can help to maintain self-control in tempting situations (Papies & Hamstra, 2010; Van Koningsbruggen *et al.*, 2011). In a rare illustration of the elicitation of people's own words, Hoffman, Baumeister, Foster and Vohs (2011) obtained accounts of occasions when desire to break a resolution was experienced in everyday life and found predicted interactions among temptation, cognitive ambivalence, resistance (self-control) and mental enactment of behaviour.

This is all support for the generic idea that a lapse from healthily changed eating or exercise is more likely to occur after some factor has disrupted the cognitive control of that pattern of behaviour.

1.8.2.2 Dietary deprivation

Another explanation why chronic dieters eat more icecream in the restraint test was that they are continually below their threshold for hunger from food deprivation (Herman & Mack, 1975). Whether this 'threshold' is biological can be questioned but past cycles of weight loss and regain make a major contribution to scores on the original dietary restraint questionnaire (Herman & Polivy, 1975). The restrained undoubtedly see themselves as self-deprived of food in the sense of eating small amounts and/or waiting long times between their meals. Hence, once restraint has been broken, that sense of continuous food deprivation can come to the centre of attention, resulting in greater food intake. These ideas are supported by findings that chronic dieting relates directly to perceived deprivation of food (Markowitz *et al.*, 2008) rather than to actual restraint of food consumption (Stice, Cooper, Schoeller *et al.*, 2007; Stice, Sysko, Roberto *et al.*, 2010).

Hence a major reason why dieters eat more than non-dieters could be that their meals are unsatisfying. This possibility is supported by the study of Carels and colleagues (2001) in which reports of low satisfaction after meals and increased hunger preceded occasions of lapse from dieting to larger extent than other eating occasions. It follows that meals that do not satisfy appetite could be among the facilitators of occasions of lapsing, among dieters at least.

1.8.2.3 Emotional overeating

An alternative explanation of dieters' overeating of icecream in the restraint test (Herman & Mack, 1975) is regret and other negative emotions following the violation of their diets by drinking the initial milkshake. Eating the icecream could then be self-therapy for anxiety, sadness or guilt. Herman and Polivy (1975) explored this idea by applying stress before offering icecream. Again, chronic dieters ate one and a half times as much icecream as non-dieters.

Research outside the laboratory indicates a considerable role of negative emotions in extra eating by those who persistently attempt to diet. Recorded lapses from dieting were preceded by stress, nervousness, deprivation and/or sadness (Carels *et al*., 2001). In later study, emotions reported to precede lapses were again feeling stressed, nervousness or sad, but also feeling frustrated, bored or restless (Carels *et al*., 2004). In a study based on records of eating occasions, Tomiyama and colleagues (2009) found that each point increment in the restraint score increased by 5% the likelihood of eating in the current hour when participants reported greater negative emotions, e.g. being sad or 'down.'

In a study with a complementary design, when dieters reported being angry, nervous, stressed, upset, irritable or being depressed, their meals were 73% higher in calories than when participants reported neutral mood (Patel & Schlundt, 2001). Nevertheless, the variance explained by each state of affect (15-5%) was less than the variance explained by the number of people present (48-34%), with no statistical interaction between emotional states and people present.

Effects of positive emotions on eating among dieters have been less documented than negative moods. In the study by Carels and collaborators (2004), occasions of lapse were also preceded by reported mood of being in control, happy or relaxed. Patel and Schlundt (2001) found that meals for which dieters reported being excited or happy were a fifth higher in calories than meals in which they reported neutral mood. In a laboratory study, Yeomans and Coughlan (2009) tested how much popcorns and raisins their participants ate while watching a

20-min film that induced either anxiety or humour. Consistently with other studies, in the anxiety-inducing condition, dieters who attributed to themselves a tendency to overeat ate 70% more food than non-dieters. However, in the humour-inducing condition, they ate 25% less food than non-dieters. These results are consistent with dieters eating more when they are anxious than when they are relaxed, whether or not good mood actively suppressed intake. Moreover, the participants were told that mood as well as sensory aspects of food would be assessed; that might have altered their eating and so it remains to be confirmed that mood-induction unawares alters the amount that dieters eat.

Regarding the exercise prescribed in a weight control programme, Conroy and colleagues (2007) reported that increased levels of stress and depressive symptoms were associated with relapsing to inactivity.

1.8.2.4 Mental vitality

One of the most obvious potential explanations of failure to maintain reduced energy intake and increased energy expenditure is that the change is so large that it is too difficult to maintain. It is widely thought that great mental effort is needed to keep up such a large change in habits of eating, drinking, movement and stillness. Indeed, Conroy and colleagues (2007) found that large proportions of the participants who lapsed from prescribed exercise in a weight control programme expressed difficulty in maintaining the diet also prescribed (55%) and in controlling their weight (43%).

There is considerable evidence that the effort needed to deal with something difficult leaves little capacity to perform other challenges satisfactorily (Baumeister, Vohs & Tice, 2007; Mann & Ward, 2000; Inzlincht & Gutsell, 2007; Erskine 2007). For instance, in a study by Baumeister and colleagues (1998), participants ate either radishes or chocolate chip cookies while both foods were visible, and then they tried a puzzle that was unsolvable. Participants who ate radish gave up on the puzzle almost twice as fast as participants who ate the cookies. Assuming that the participants regarded the radishes as healthier but more difficult to eat than the cookies, this result fits the notion that making changes in eating or exercise could reduce mental energy and consequently the ability to keep control if a challenging situation comes up.

A variety of mental and environmental conditions (e.g. 1.8.2, 1.8.3) could make the change in frequency of a habit into a heavier cognitive burden on the individual. So, exhaustion of mental vitality (i.e. mental fatigue) needs to be investigated as a factor in a lapse.

1.8.2.5 Physical vitality

In the above-cited study by Conroy and collaborators (2007), the participants in the weight control programme reported whether or not they had lapsed for more than two weeks from the prescribed exercise. A total of 61% of participants reported lapses, of which 39% did not resume that exercising. Participants who lapsed from the exercise reported higher levels of fatigue than participants who had not adopted the exercise.

The level of other physical activity over time might influence the maintenance of extra exercise. Perri and collaborators (2002) observed lower adherence to high levels of physical activity than to moderate levels. This is consistent with the possibility that increased muscular fatigue can discourage maintenance of any additional exercise routine.

In addition, people might seek to gain or restore physical vitality consuming food or calorific beverages, especially if marketed as energy drinks. Thus extra eating is likely if people feel physically tired. Carels and colleagues (2004) reported that exercising was an activity that preceded occasions of lapse among dieters. They also found that being tired was among the perceived states that preceded lapse. Patel and Schlundt (2001) found that meals were 7% higher in calories when dieters reported being tired and weak than when they expressed neutrality in mood. A limitation of these findings is that the scores from ratings of tiredness or weakness were combined with those for other moods to form a scale called 'anxiety.' So, there is a need for further investigation of the possibility that feeling physically weak or tired contributes to lapses from changes in eating patterns with the intention of reducing weight.

The research into the roles of conscious or unconscious cognitive states in lapses from reduced intake or increased expenditure leaves open the question if those states are characteristically evoked by particular factors in the observable factors in the social and physical environment. Indeed, cognitive states would ideally be measured by calculation of the processes by which observed stimuli are converted into observed responses (Booth & Freeman, 1993); however, such analysis goes beyond the scope of this thesis. The first step needed is the characterisation of perceived or recalled aspects of the context of a lapse that might have contributed to that change back in the behaviour.

1.8.3 Environmental factors in lapses

Gaps in evidence on influences from the internal environment were considered earlier (1.7). Now some examples are considered of research into external societal and material

influences on overeating or under-exercising, particularly among slimmers or those who chronically restrain their eating.

1.8.3.1 Presence of people

There is evidence from correlational analyses of records of meal occasions that the number of people present is proportional to the amount that they each consume (de Castro (1990, 1994). Women in a weight loss programme have shown a qualitative effect in their records: meals with family or friends were a quarter to a third higher in calories than meals eaten alone (Patel & Schlundt, 2001). In experiments on this effect, the greater the number of people, the more time is spent eating (Feunekes, de Graaf & van Staveren, 1995). Yet mere time is not a cause; the question is what the people or the durations do (physiologically and/or socially) that raises intake.

A person could increase intake by imitating how much food is eaten by the others around (e.g., Hermans *et al*., 2008). However, this explanation is insufficient: the effect of the modeller could be either facilitatory or inhibitory. Another explanation might be distraction from controls that are operative while eating alone, such as physiological signals or social norms of satiety. There is some evidence that modelling and distraction can operate simultaneously: while talking with a friend or stranger of the same gender, men ate 70% more cookies or crackers with the friend than with the stranger, whereas women ate 34% more (Salvy *et al*., 2007). It remains to be seen if this effect is magnified when there are two other people to talk with, and further when there are three.

Some effects of other people do not depend on their presence. The influences come from what others are believed to do, such as how much food is appropriate to eat. For instance, Feeney, Polivy, Pliner and colleagues (2011) told participants who were offered pizza to eat while watching TV that ten prior participants had eaten about three pieces of pizza (less than average). They found that participants in this condition ate 37% less pizza than control participants who received no information about how much other participants had eaten.

1.8.3.2 Time of day

Proximity to conventional or habitual mealtimes would be expected to have a variety of ways of affecting lapses from eating less, and indeed from exercising more. Dieters express stronger dispositions to eat than do non-dieters (Odgen & Wardle, 1990). Perhaps the approach of a mealtime increases awareness of forthcoming access to food or the length of time since the last meal (1.8.2.2) and this raises ratings of hunger or responsiveness to

physiological signals of depletion more in dieters than in others. Also, conversely, depletion signals might alert people to the prospect of their next meal, whether by eating-specific associations or by a general mechanism of personal goals activate the time of their attainment (Jonas & Huguet, 2008).

A classic experiment showed that just the time read from a clock, in the absence of direct social cues, can increase eating in people who are likely to be dieters. Overweight participants ate twice as much after than before what they believed was their usual dinner time, as a result of the room clock having been speeded or slowed before the eating test (Schachter & Gross, 1968). Hence a lapse from eating less may be more likely as a meal time approaches.

1.8.3.3 Location

Eating out in general and use of fast food outlets in particular have been widely blamed for obesity. Lack of safe places to walk or cycle has also been suspected of contributing to obesity. Hence some research has explored the effects on weight gain or energy intake of such locations. For example, frequency of use of fast food restaurants over three years was positively associated with body mass index (BMI), an indicator of fatness, and with an estimate of energy intake (French *et al*., 2000). More recently, frequency of eating away from home, at places such as restaurants, cafeterias, bars and fast food outlets has been positively associated with BMI and estimates of energy intake (Chan & Sobal, 2011; Naska, Orfanos, Trichopoulou *et al.*, 2011).

The gap in research is systematic investigation of effects of particular settings on eating or exercise. Furthermore, it is scientifically erroneous to attribute influence to the location as such Research needs to characterise specific social or physical factors in the setting that affect particular patterns of eating or exercise, especially lapses from weight-reducing changes in the frequency or intensity of widely recognised patterns of eating and exercise.

1.8.3.4 Presence of foods

Unlike exercise, eating is constituted by use of material items, regarded as food. Foodstuffs (and drinks) have physicochemical characteristics that are sensed and integrated into the identity of the food, to which concepts are attributed such as filling, nutritious, rich in fat and suited to the dish, the mealtime or those eating. Some research indicates that the responsiveness to the sensing of food cues may be heightened among chronic dieters, especially smell (e.g., Fedoroff *et al*., 2003) or sight (e.g., Thomas *et al*., 2011). Sight, smell

and immediacy of access could all have contributed to laboratory findings such as those of Nisbett (1968): overweight participants were presented with a bottle of soda and either one or three sandwiches, and told there were more sandwiches in the fridge to eat if they wanted; those faced with three sandwiches ate over half as much again more than those with one sandwich.

There appears to be no research on the influence of the presence of food on lapses from eating less frequently in a particular way, unlike work on contribution of sensory cues to lapses back to use of drugs such as nicotine in cigarettes.

The principle may also be relevant to lapses from exercising. Sight of a comfortable chair or the trailer for a TV programme, for example, could trigger a lapse to more frequent sitting. Furthermore, instigators of underexercising and overeating are suspected of overlapping, as in eating snackfoods while watching video.

1.9 Addressing the gaps

It is of course impossible for a single project to address all the limitations of previous research into weight control. Nevertheless there may be approaches that gather evidence systematically on the causal processes involved. The empirical work for this thesis investigates key components of such an approach, outlined in Chapter 2, and illustrates how those components can be integrated into comprehensive experiments in real life.

CHAPTER 2
REQUIREMENTS OF A NEW APPROACH TO RESEARCH ON OBESITY

2.1 Outline of principles

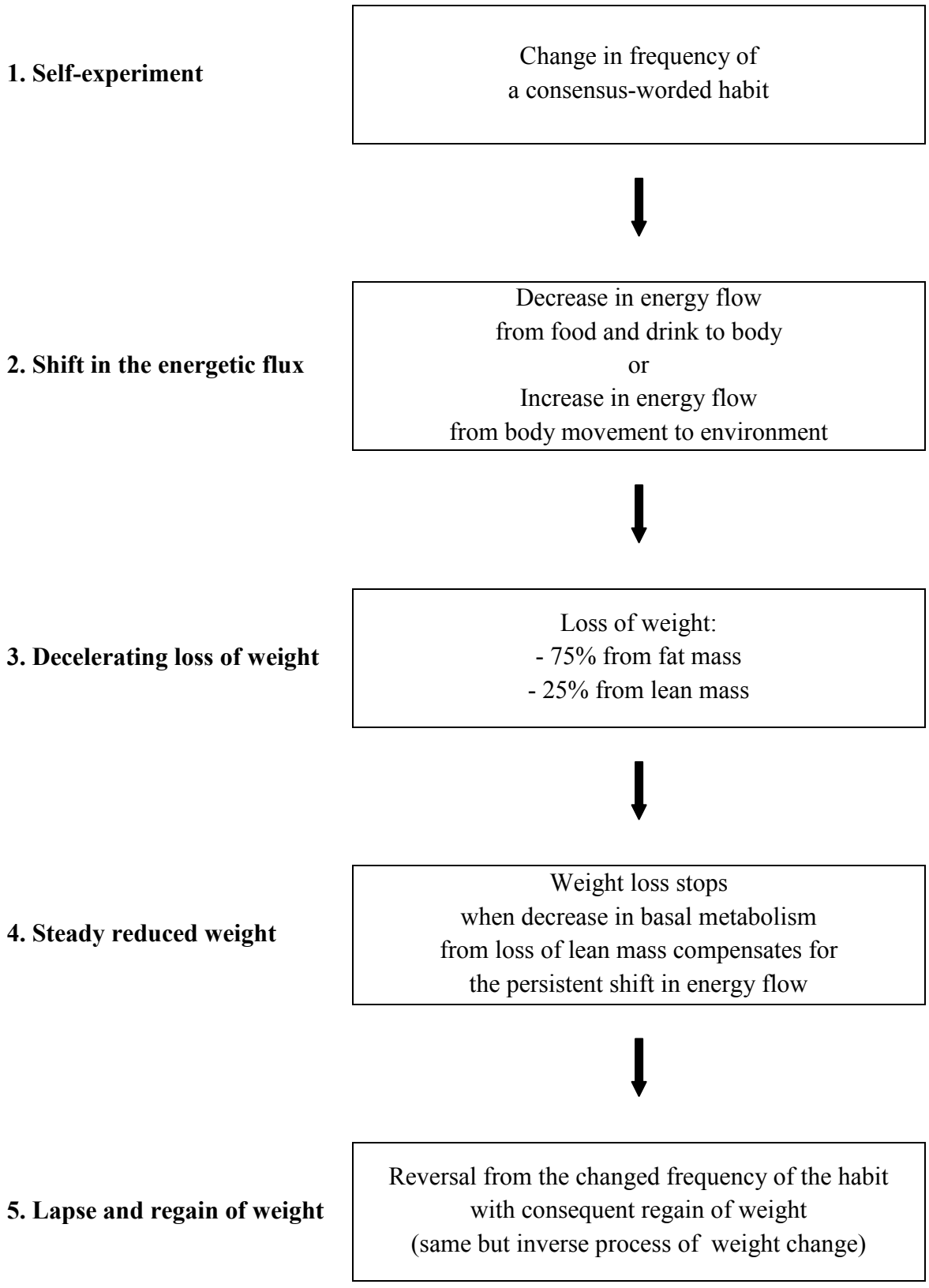
This Thesis presents the development of an innovative approach to gathering evidence that can help to prevent and permanently reduce unhealthy weight among members of the public. The gaps in existing research identified in Chapter 1 could begin to be filled by appropriate analysis of data from individuals who are experimenting with the effects of their habits on their weight (Figure 2.1, Box 1). They can find out for themselves if a sustained change in frequency of a habit works for them in losing weight, by regularly recording their weight and their recall of the most recent occasions of each relevant habit. If they wish to copy that record to the research team, the effect on weight of a sustained change in frequency of a habit can be measured by combining individuals' data from their self-experiments on the same habit.

Systematic use of these records of individuals' weight and occasions of relevant habits can identify (i) which changes in frequency of particular habits reduce weight and (ii) the context of such change. This evidence could also be used to counsel people from the studied locality how to reduce weight using descriptions of eating and exercise habits with which they are familiar.

The basic logic is that change in how often someone carries out a particular habit alters the flow of energy out of or into the body (Figure 2.1, Box 2). Since energy cannot be created or destroyed, its stores in the body must change when the frequency of a habit changes (Figure 2.1, Box 3). About a quarter of any weight change for more than a few days is tissues that expend energy (Garrow, 1978). Hence, as weight is lost, energy output goes down and, if the decrease of energy intake or increase in exercise is maintained, the loss will slow and eventually stop (Figure 2.1, Box 4).

On the same principle, if the weight-reducing change in frequency is not maintained, weight will be regained (Figure 2.1, Box 5). A decrease in weight will not affect disease consequent on obesity unless it is long lasting. Hence, to support maintenance of change and thus reduce the disease risks of obesity, causes of occasions of lapsing need to be elucidated. As the first step in such research, participants record their recall of the most salient mental and physical context of the occasion of a habit when its frequency reverses from the self-experimental change.

Figure 2.1 Effect on weight of change in frequency of a habit.



2.2 Consensus on accounts of eating and exercise patterns

The proposed approach to reduce unhealthy fatness begins by identifying the words used by members of the public to describe their customary eating and exercise practices in everyday language (Chapter 1, section 1.2).

Social anthropologists acknowledge the ecological validity of individuals' accounts in agreed terms of what they do in their ordinary life (e.g. Dressler, Oths, Ribeiro *et al*., 2008; Romney, Weller & Batchelder, 1986). Wittgenstein (1953) argued that the firmest available datum on what a person is doing is a description in the individual's own selection of words used in the culture. On this basis, the logically first step is to elicit descriptions of common occasions of eating and exercise by recall of specific autobiographical events. Then consensus on those wordings is sought, in order to identify a pattern of eating or exercise that is recognised in that culture.

The problem for patterns of exercise, and even more for patterns of eating with so many foods to choose among, is to reduce the descriptions to a manageable number of categories without leaving out a type of energy expenditure or intake that could have substantial effects on weight. Many studies use classifications by the research team or even the individual investigator (Chapter 1, section 1.2). Strauss and Corbin (1998) proposed such a method for 'qualitative' analysis of narratives of personal events. Blake and colleagues (2007) created a classification of foods according to the contexts of their use. However, the foods and the contexts were selected by the researchers and so it is not known how ecologically valid their categories were. Stuckey and collaborators (2010) investigated the strategies that people specified for long term weight control. However that research team also created their own classification of the elicited practices, as part of the qualitative procedure they used.

A method is needed for a representative subsample from the same locality to categorise the elicited descriptions of eating and exercise. Individuals presumably classify their activities by requiring the matching of descriptions to representations in memory (Shipley & Zacks, 2008). To affect weight, a pattern of behaviour has to be repeated often. That repetition will form a habit (Neal, Wood & Quinn, 2006). If the behaviour is repeated in a particular context, the salient features of such a scenario will be retained as a configuration in memory (Alba & Hasher, 1983). People usually recall the most salient information (Wagenaar, 1986; Brown-Kramer, Kiviniemi, Winseman, 2009). The most accurate reconstructions of eating occasions in the previous 24 h were for the foods that were recalled

first (Fries, Green & Bowen, 1995). Indeed, the evidence is that events are put into categories ('parsed') by identifying changes in the configuration of features from one event to another (Kurby & Zacks, 2007). The importance of perceived contextual features can be measured by discrimination scaling (Booth & Freeman, 1993; Booth, Sharpe, Freeman & Conner, 2011). In the present context, words and phrases within each description can play a greater or lesser role in classifying two elicited accounts as being of the same behaviour. Such hypotheses were tested in a consensus-seeking experiment in Chapter 4.

In a similar way, to communicate effectively with people in research studies, such consensus-worded behaviours are used in questionnaire items for matching them with participants' respective mental representations. It should take little effort to process familiar descriptions. More importantly, the words used by the investigator to enquire about a piece of behaviour are the same as those used by the participant to refer to that pattern of activity. In this way, a specified custom can be tracked separately from other behaviour. Thus, the effect on weight of specifically its change in habitual frequency can be measured.

The clarity of the wording used to promote change is also a central aspect of influencing behaviour (Myers, 2010). A clear message reduces uncertainty about what needs to be done and what is expected from carrying out such change (Tversky & Kahneman, 1981).

2.3 Timing of a past personal activity

To estimate the effect of a specific habit on body weight, a change in frequency of the habit must be observed (2.1). Hence this research relies on data about the timings of occasions when that pattern of eating or exercise was carried out. In this thesis, the intensity of the habit is assumed to be sufficiently constant across occasions – for example, the amounts and compositions of foods and the duration and vigour of movements. At least spot sampling to check this assumption will be necessary in further developments of this approach.

Reconstruction of past events from memory inevitably can be less reliable than reconstruction from a good record made at the time. However, the recording of events that are as complex, significant and frequent as episodes of eating or drinking and moving or sitting is liable to disrupt those activities. Less important theoretically but a serious logistic issue, recall of only the most recent occasions is less labour and more efficient than recording all events and then picking out only the most recent.

2.3.1 Autobiographical recall

Information about past events specifies what Tulving (1972) called "episodic memory" as distinct from memory of facts without necessarily recalling the occasion of

learning the remembered fact. A proposed basic mechanism of recall is that certain aspects of a past event are highly accessible in memory (Conway, 2009). Skowronski and colleagues (1991) observed a match of 90% of the recalled aspects of a variety of recorded activities during the previous 6 days. Studies of the recall of foods that were eaten show an accuracy of 80-90% over about a week (Smith, Jobe & Mingay, 1991; Armstrong, MacDonald, Booth *et al.*, 2000).

This research requires the date and time of day of an episode of a particular habit. That depends on the recovery of extensive information about different aspects of the event (Friedman, 1993). Hence the specification of the occasion to be recalled needs to be rich in detail that provides non-leading prompts to reconstruction of that event, such as a characterisation of the type of meal.

Recall of the timing of an episode such as an eating occasion or a bout of exercise is also improved by reinstating the context by prompts such as *where was it?* or *who else was present?* (cp. section 2.2; Armstrong *et al.*, 2000). This principle is the basis of the Cognitive Interview (CI; Fisher & Geiselman, 1992). The CI consists of a structured series of questions that serve as mnemonics such as time of day, location, people present and other features particular to one autobiographical incident. This deep probing of memory for a specific occasion (at any time in the past) also helps to prevent the inaccuracies that arise from constructing answers merely to a question like *how often do you ...?* (cp. Chapter 1, section 1.3).

The accuracy of recall of autobiographical events decreases with time since the event (Rubin, 1982; Thompson, 1982; Wagenaar, 1986; Skowronski *et al.*, 1991; Kristo, Janssen & Murre, 2009). Those studies also showed that the precision of recall of each feature of the occasion declines over delay. The mechanism is likely to involve confusion between aspects of similar events at different times, whether or not some decay of the 'memory trace' also occurs. Such confusion might be reduced by non-suggestive prompting of recall of details of the event, as in the CI. However, such weaknesses in older memories are less important for the present research, because the longer ago the latest occasion of an activity, the lower is the current frequency and so the less that the habit contributes to the rate of exchange of energy between the body and the environment.

2.3.2 Measurement of the frequency of an eating or exercise pattern

The current frequency of a customary practice is needed to investigate the effect of change in its frequency on weight (Chapter 1, section 1.3). For instance, if the time between

the two most recent occurrences of a habit is shorter than the time between the two most recent occurrences at a later time, then the frequency of the habit decreased from the first period to the second.

To calculate a frequency, the timings of at least two consecutive occurrences of a particular pattern of eating or exercise are needed. The length of time between the two most recent occasions of a pattern provides the basic datum for calculating how often such habit currently occurs over the period between the two times (Blair & Ganesh, 1991; Booth & Platts, 2000). The reciprocal of that interval between occasions is the frequency of such events.

Hence, just two initial questions are necessary to seek information from which to estimate the current frequency of a habit: (1) *when did you last* [description of habit]*?* and (2) *when was the occasion before that?* However, the accuracy of the recall of the timings is likely to be improved by asking for the timing after questions about aspects of context (such as where and with whom) and specifics of the occasion, such as how fast was the walking, which TV programme was watched, or which foods and drinks were consumed. As a minimum, the wording of the habit should if possible indicate the time of day or the relation to mealtimes or other fixed times, e.g. "breakfast", "between meals", "on the way to work."

2.4 Recorded weight

The weight that is relevant to the role of behaviour in obesity is the reading on weighing scales when used in a standard state of the body (cp. Chapter 1, section 1.4). Hence the approach of this Thesis is to ask participants to record the reading that they see on the scales under those conditions. Only a few studies so far have obtained this basic scientific datum about body weight in everyday life (McGuire, Wing, Klem *et al.*, 1999; Rothert, Stretcher, Doyle *et al.*, 2006; Befort *et al.*, 2008).

These recorded weights are capable of detecting group-average changes in weight over a period of months. For instance, an online weight control intervention that used self-readings of weight found a difference in weight change at three months between groups with tailored advice and general information only (-2.6 ± 0.3 kg *vs.*-1.2 ± 0.3 kg; Rothert *et al.*, 2006). Reliable effects of behaviour change on recorded self-weighings in this project will further validate the accuracy of this method.

The reliability of readings from the same scales has also been measured. The variation in successive reading is less than 0.5% (Harris *et al.*, 1998), i.e. less than 350 g for a person weighing 70 kg. The finest graduations on bathroom scales (and public scales) are generally

0.5 kg (1 lb) and so this average is similar to that to be expected of the most precise single reading.

Clearly, the setting of a standard condition is crucial. Shoes and clothes can alter the weight reading by 1-2 kg (Rissaneau *et al.*, 1988). Ingestion of food or liquids before weighing will add to a reading made after absorption has ended, e.g. before breakfast. Excreta in the bladder and bowel can add up to 500 g (Edholm, Adam & Best, 1974). Hence, to minimise extraneous variation, the participant should wear no shoes and the same light clothing or none and have an empty stomach and bladder. Also of course nothing else must be touched when the reading is taken standing on the scales and they must be on a flat surface.

The present research relies on consistency in weighing within individuals, not on group means. The evidence for effects of behaviour change on weight comes from combining individuals' changes in weight across people. Also the relevant changes are over weeks, rather than months or years. In any case, bathroom scales seated horizontally on a firm surface have zeroing and calibration that are robust in the long term.

2.5 Exchange of energy between the body and the environment

The proposed thermodynamic theory of weight control (Figure 2.1; Chapter 1, section 1.5) operates on the frequency of the habit over time. Any sustained difference between the rates of energy intake and expenditure must result in a change of body weight. However, that difference will decrease as the resting metabolic rate from lean tissue changes with weight and so the weight change will slow down and eventually cease. In other words, the individual will show no further change in weight when the lean mass has approached the level that compensates the shift in the flux of energy exchange. Hence, a reduced rate of intake or an increased rate of expenditure originated by a maintained change in the frequency change of a habit will reduce weight to an asymptote. That is, the adoption of a slimming habit produces a step change in weight, not a continuing accumulation of the amounts of energy omitted from intake or added to expenditure.

Thus, to measure the effect on weight of a change in frequency of a particular pattern of behaviour, weights and frequencies must be monitored while the behavioural change persists and until the weight has reached asymptote. This has not been done in any published study (1.5).

The key to the approach of this Thesis is therefore the tracking of weight and frequency while those processes are occurring and using the data to measure the strength of any influence of a particular piece of behaviour on weight. Change in weight may reach

asymptote within a few weeks of a change in environmental temperatures and clothing, diet and/or exercise (1.5). Hence, to observe any correlation between changes that are causally connected, weights and frequencies have to be measured at intervals of no more than a month. As we shall see (2.6.1), monitoring at no more than weekly intervals is essential to identifying the direction of influence (from behaviour to weight, not weight to behaviour) for a weight asymptote at 3 weeks after the start of change in behaviour.

2.6 Effect on weight of change in frequency of an eating or exercise pattern

2.6.1 Correlation as evidence of causation

Experimental designs differ from observational designs in how specific the observed differences are to the hypothesised cause. In either case, the evidence of an effect is a reliable correlation between differences in the two variables. Even when there are only two values of an independent variable, a regression exists between those two values of that predictor and the values of the criterion (the dependent variable) observed in the participants.

Parallel changes in frequency of other patterns can arise from the replacing of one pattern by another (Booth *et al.*, 2004), e.g. high energy density snack foods by fruit, or sugar sodas by water or diet sodas. Alternatively, they can represent habits that relate conceptually, e.g. as healthy eating. These combinations of changes have to be treated as a single variable in causal analysis.

A reliable positive or negative correlation between two variables shows that there is a causal connection between them. However, it does not identify the direction(s) of influence(s). The correlation does not even show that either variable influences the other: their covariation might be caused by a third variable. The only way to obtain evidence of causal direction is to use the principle that an effect starts after a cause starts, on the time scale relevant to the mechanisms involved (Granger, 1959; Lawler & Suttle, 1972). In the case of energy exchange, the change in weight is likely to take hours at the minimum to follow from the change in frequency of a habit. If at least part of a correlation survives a time lag, that indicates the first-started variable influenced the second-started variable. Two-way influences are possible. If neither lag gives a correlation, where simultaneous starts showed one, that could be evidence that a third factor caused the observed ‘concurrent’ correlation

To obtain evidence on the direction of causation from a time lag between behaviour change and weight change, and from crossing with the reverse lag, at least one measure is needed between the start of behaviour change and the end of weight change. Hence monitoring at no longer intervals than weekly is essential to this causal diagnosis. Tracking

twice a week or even daily would be safer in case there is a rapid step change in weight, attributable to water occluded by liver glycogen rather than to changes in fat and lean mass (1.6).

2.6.2 Size of effect of behaviour change on weight

The term "effect size" is generally used in a statistical sense, to refer to the amount of variance in an outcome that is explained by a manipulation. The simplest measure of effect size is the linear regression coefficient, β (beta), going from +1 to -1. In multiple regression (not used in the present approach), this is a partial coefficient for each predictor. In the case of a single predictor, β is the correlation coefficient, r. In the special case of regression with fixed values of the predictor - namely, analysis of variance - the effect size can be measured as the difference between means divided by the standard error of the mean or standard deviation or as the squared deviates from the partial regression line, ${}_p\eta^2$ (partial eta squared).

However, these statistical values contain no scientific information about the amount by which the outcome has been affected by the manipulation. Research on weight control needs to measure the asymptotic change in weight that results from a particular change in frequency of a culturally recognised pattern of eating or exercise. This measure also is provided by the regression from change in frequency to change in weight, as the slope of the line fitted to the data by least squared deviates, b (the lower case of the Roman letter; statistical packages confusingly vary in substituting an upper case B for the coefficient β or for the slope b). This scientific measure has been called the "dose-response" (French *et al.*, 1998). The numerical value of the slope of the regression line depends on the units of weight and frequency put into the calculation, e.g. lb, kg or g and daily, weekly or monthly. So they are not restricted to the range +1 to -1.

2.7 Multiple baseline measurement of differences between habits in energy exchange rate

The change in weight caused by a change in frequency of a habit comes from the resulting change in rate of energy expenditure or intake (average calories per day or week). This section of Chapter 2 reviews the literature on experimental designs for testing hypothesised contrasts between habits in sources of energy (1.7).

The basic design was first used in studies of small numbers of single cases in the Skinnerian tradition; it randomises the timings of the experimental manipulations across individuals (Barlow, Nock & Hersen, 2008). In the simplest form of the design for just two types of manipulation (including experimental and control), one individual undergoes the two

conditions in one sequence and the other case has the two manipulations in the reverse order. To measure an effect, both the manipulated variable (habit frequency in this Thesis) and the effect (body weight here) have to be steady before the manipulation is made. These steady levels are called 'baselines.' Since there are two or more manipulations and more than one effect may be monitored, the design is commonly called 'multiple baseline.' The second manipulation can only be introduced after all the variables have reached another steady state, whether different from or the same as any or all of the original baselines.

Conventional or prescribed dieting to reduce weight may involve simultaneous changes in several eating and drinking practices and maybe a concurrent increase in some exercise too (Stuckey *et al*., 2010). This multiplicity prevents good compliance. Participants in a weight loss programme who perceived the prescribed slimming strategies as complex were almost certain to withdraw (Mata, Todd & Lippke, 2010). Once again, there is little appreciation in the literature that changes in behaviour have to be made one or two at a time, not only to test their effects on weight and potential factors in lapsing, but also to ensure that they can be adopted as permanent changes in lifestyle.

Simultaneous changes make each of the changes difficult to investigate. If two pieces of behaviour are changing at the same time, this correlation confounds the experiment. The manipulation then has to be treated as a combination of changes – that is, a multivariate such as a principal component in factor analysis of all observed frequency changes. Eating and/or exercise habits may change in frequency together because the participant is operating under a concept - for example, an idea of healthy eating that involves several habits.

Hence it is impossible to analyse causally the separate components of such packages of behaviour change unless the changes are implemented in sequences varied across people. Therefore, a critical part of the design is that only one manipulation occurs at a time. Furthermore, each component has to be continued through its step decrease in weight before starting to implement another component.

To go on further to investigating the mechanisms by which habits affect weight, hypothesis-testing experimental and control conditions must be compared. These can be two habits with higher and lower levels of a known rich or poor source or sink of energy or of another factor affecting energy inflow or outflow.

2.7.1 Energetic efficiency of fat

Since fat is more fattening than carbohydrate, decreasing the proportion of dietary fat in regular meals by increasing carbohydrate and protein within the same total energy should

raise the energy expenditure rate (1.7.1.1). To test the effect on weight of the energetic efficiency of dietary fat, participants who know what meals have a large content of fat can be asked to reduce the frequency of meals high in fat (DownHiFat). As a control condition, the participant might be asked to reduce the frequency of meals high in carbohydrate, and therefore in practice also low in fat and in protein (DownHiCHO). The hypothesis is that reduction in frequency of HiFat produces greater weight loss than decrease in frequency of HiCHO. It must be noted that this contrast only tests the low energy cost of depositing dietary fat as adipose fat if the two sorts of meals have the same energy contents on average. This means that the high-carbohydrate meals are likely to be considerably bulkier than the high-fat meals.

2.7.2 Energy not compensated between meals

Eating and drinking less often at the timing when energy intake is not (so well) compensated should decrease the rate of energy intake (1.7.1.2). The effect on weight of ingesting energy between meals is tested requesting the decrease in frequency of snackfoods and energy-containing drinks between meals (FewerEnBM). The control condition needs to reduce the frequency of the same sort of snackfoods and energy-containing drinks but just within meals (FewerEnWM). The hypothesis is that decreasing the frequency of ingestion of snackfoods and energy-containing drinks between meals should reduce more weight than doing the same within meals.

2.7.3 Energy at mealtimes: breakfast, lunch and supper

Increasing weekly frequency of a main meal at *breakfast time, lunch time* or *dinner / supper time*) up to the highest group frequencies might enhance the compensation of energy from meal-to-meal. To distinguish the effect on weight among these mealtimes, they have to be tested separately. Eating once in the evening (e.g. *dinner* and *nightcap*, or *tea* and *supper*) is may be a pattern that helps to avoid unhealthy fatness. Decreased frequency of eating twice or more before going to bed might decrease the energy exchange rate through cutting down on uncompensated energy. Lowering the frequency of the pattern of eating more than once in the evening should therefore reduce weight. However, since almost everyone eats at least once in the evening, the changes requested might have to be in the opposite direction, expected to produce and tested for an increase in weight.

2.7.4 Intake-reducing effect of late satiety from protein

The hunger-delaying effect of protein on weight (1.7.1.3) is tested by increasing the frequency of high-protein meals (MoreHiPro). To disconfound effect of protein from the

effect of fat in the HiFat condition, the HiPro condition is also low in fat. Carbohydrate does not suppress hunger late after a meal as fat and protein do (Cotton *et al.*, 1994). Thus, high-carbohydrate meals (HiCHO) can be used as control pattern (again, also as in 2.7.1) with an increase in frequency being predicted to have no effect on weight from prevention of snacking late in between meals. That is, in contrast with an increase in frequency of high-carbohydrate meals, an increase in frequency of high-protein meals is hypothesised to reduce weight.

2.7.5 Conditioning of satiety

Beginning a meal with some starch-rich food long enough after the previous meal should decrease the rate of energy intake if its learnt lowering of the size of later meals with similar desserts is not compensated later in the day (1.7.1.4). To test this mechanism, a meal that includes bread, whose crumb is 50% readily digested starch, right at the start (BdStrt) can be contrasted to a meal that includes the bread after the start (BdAftr). The hypothesis is that the increase in frequency of bread at the start should produce a larger reduction in weight than the increase in frequency of bread later in the meal.

2.7.6 Walk fast

The sustained raise in frequency in the pattern of walking fast between locations should reduce weight as an effect of increased energy expenditure rate over the whole day and maybe during sleep as an after-effect.

2.7.7 Move around rather than sit down

The increase in frequency of getting on with movement whenever possible, rather than sitting, is predicted to raise energy expenditure enough to reduce weight observably.

2.7.8 Stairs rather than lift/escalators

The hypothesis is that, unless people rested more after using stairs, the accumulated daily cost in energy from a maintained increase in frequency should cause weight loss.

2.7.9 Housework

If doing housework is not compensated by extra resting, the increase in its frequency is liable to raise the rate of weekly energy expenditure and thus to reduce weight.

2.7.10 Exercise of high intensity

Doing recreational activities of high intensity more often should raise the rate of energy expenditure unless it was fully compensated by resting. The increased frequency in local recreational practices involving energetic exercise can be tested for decrease in weight.

2.7.11 Salt in food (without fat)

There is no theoretical reason for changes in salt intake to affect energy exchange. Therefore this practice can be used as control condition for testing the effect on weight of any mechanism.

2.8 Maintenance of change in behaviour

This research is focused on evidence for effects of specific behaviour on weight. Nevertheless, to avoid the harmful effects of obesity, a step change in weight has to be sustained indefinitely, beyond the period of observation or intervention (Chapter 1, section 1.8). Therefore the data collected for the primary purpose are also used to assess the persistence of a change in frequency of a habit affecting weight. In particular, the plan is to explore potential causes of lapsing back from a change (1.8).

2.8.1 Evidence on the feasibility of change

Each participant contributes from the start to a sample of existing frequencies of engagement in the monitored habits. In each case, higher frequencies are characterised by national guidelines either as healthier than lower frequencies or as less healthy (Klein, Sheard, Pi-Sunyer *et al.*, 2004). Previous evidence could also categorise direction of change as slimming or fattening (Chapter 1, section 1.7). In due course, a locality's most effective patterns for reducing weight will be identified properly by measurement of the grams of weight lost per change in number of times a week that a specific eating or exercise pattern is carried out more or less than previously.

The range of the changes in the frequency of a habit to be maintained that are chosen by participants provides a measure of the feasibility of sustained change, as expected by participants. Change in frequency may be harder, or perceived to be harder, for some patterns of eating or exercise than for others. Furthermore, perceived difficulty might differ in general between eating and exercise, when measured in comparable units or slopes.

Ahead of such evidence, the participants could be informed of the range of existing frequencies (at least on the healthy side) before making a decision about the extent of change to make and to maintain (perhaps beyond the duration of the experiment). This information could work as a social influence on a healthy change in a habit. Personal choices of foods and amounts may respond to reports about what others have eaten (1.8.3.1). Such factors are liable to vary among habits.

2.8.2 Evidence from persistence of change during tracking

Once a change in frequency of a habit has been implemented (substantial change has ceased), then the period at a new steady frequency might in principle change in either direction before observations end. The distributions of durations of change could be separated between the start of such change and a further change in the same direction as originally or a reversal of change – in other words, lapsing from the initial decision. Survivor analysis might pick out diverse types of factor in intensification of change or in relapsing. The survival functions are liable to vary among habits. Marked disparities between effectiveness on weight and ease of maintenance would be of practical importance. They might also point to differences between activities in causes of lapsing from weight-reducing change.

2.8.3 Characterisation of causes of non-persistence of change

When records are reported frequently enough, the occasion initiating a frequency change can be identified and the participant approached for more information about that event. Existing theories about triggers of overeating or underexercising (Chapter 1, section 1.8) could be explored by asking for recall of the circumstances. These opinions why the lapse occurred could give considerable insight into potential causal factors that are open to subsequent objective investigation – that is, observable in the environment. Thus, participants should also be asked to recall the circumstances of the lapse, whether or not they consider them to be relevant.

Recall is a useful tool for exploring the observable context of past personal events (Knibb & Booth, 2011). Unless participants regard the lapse as too embarrassing or despicable even to record and copy anonymously, there is no reason to doubt the truth of the responses. Recall of a lapse has the same advantage as recall of any incident: it does not interfere with the action, as making a record at the time can do.

As always, the first response to elicit is the participant's own wording for perceived factors in the lapse, by a non-leading question such as "What was on your mind when you [*description of habit*] on [*recorded date and time of day*]? or "What do you think influenced you to …?"

Then specific questions could be asked about aspects of observable context that may or may not have been remembered before they were mentioned, e.g. location, others present, nature of the movement, foods and drinks consumed (2.3.1). Differences among habits in the most prevalent context for lapsing could be pursued in more structured investigations.

Finally a list of hypothesised factors (1.8) could be presented for ticking, ranking or rating their perceived relevance to the lapse.

2.9 Aims of this Thesis

This Thesis extends and improves substantially previous work carried out by Blair, Booth and colleagues on patterns of eating and exercise for avoiding unhealthy weight.

The study carried out by Blair, Booth, Lewis and Wainwright (1989) among people living in the West Midlands area of England, subsequently re-analysed by Booth and collaborators (2004), is in various ways a precedent for the present Thesis work. First, it addressed for the first time healthy practices of eating and movement reported by participants in their own terms (1.2). Therefore, the wordings of such practices referred presumably to some realities in that locality. Secondly, the study of Blair and colleagues investigated in particular the change in frequency of use of each practice (1.3) and its individual strength of association with weight change (1.4). However, as pointed out earlier (1.5), the lengthy interval between measures in Blair's study is a pervasive flaw in previous research for investigating causation (1.5). Nevertheless, they proposed a mechanistic perspective from experimental or theoretical models on how a given change in frequency of a practice controls weight (1.7). This integration of eating and exercise in normal life with thermodynamic (1.5) and physiological (1.7) theory has the prospect of generating evidence on weight control with greater ecological validity and precision than the usual less direct approaches.

Here, the major approach is to track a persistent change in frequency of any relevant pattern of customary eating or exercise in order to test the effect on weight while it is occurring. The principal aim was to measure how much the weight of the body is reduced by the decrease in energy intake or increase in energy expenditure that results from change in how often a customary pattern of eating or exercise is carried out. For this, the Thesis includes in total eight chapters based on newly collected data (Chapters 3-10) and one chapter that includes a plan for an additional study (Chapter 11).

The studies reported in Chapters 3 and 4 investigated the role of words used by the public in objective description of everyday activities (2.2). The study of Chapter 3 tested the realism of peoples' accounts of eating occasions perceived as healthy or unhealthy against the national nutritional guidelines. The study in Chapter 4 investigated the consensus of students about what wordings within occasions of eating described by the public refer to particular patterns of behaviour. These commonalities indicated wordings useful for describing the set of patterns of behaviour for their monitoring among students.

The work presented in Chapters 5-7 investigated the accuracy of recalled timings of past occasions (from which frequency of a habit is calculated: 2.3) and of recordings of weight (2.4). Chapters 5 and 6 analysed inaccuracies in recalled timings of past occasions as well as errors in their recording. The study in Chapter 7 sought for sources of bias and error in the recording of body weights shown on bathroom scales.

The experiments in Chapter 8 and 9 brought together the elements studied in the previous chapters to illustrate measurement of the size of the effect on weight of a change in frequency of a pattern of eating or exercise that could be part of an experimental design to test for a particular weight control mechanism (2.5-2.7).

Chapter 10 investigates the persistence of healthy changes in frequency of eating and exercise patterns that were observed in the studies in the previous chapters (2.8.2).

Chapter 11 presents a plan that uses the experience from the data-based chapters to design an experiment that investigates the effect on weight of self-experimental change in frequency of an eating or exercise pattern and introduces a method to investigate context of lapse from such change (2.8.3).

2.10 Ethical approval of this research

The studies presented in this Thesis were carried out in accord with the Code of Conduct of the British Psychological Society, which includes care for research participants, and the Society's Guidelines for Ethical Practice in Psychological Research. This was on the responsibility of the lead Supervisor for the School of Psychology, Professor David A. Booth, as a professional research practitioner recognised by the BPS, under the procedure approved by the School's former Research Ethics Committee for students' research within the experience of a member of staff. (PhD students starting before 2008 were not required to submit their research project proposal to the University's Research Conduct and Ethics Committee that had recently replaced the School's REC.)

The study described in Chapter 3 was conducted by face-to-face interviewing with visitors to a University's Open Day by the research students Antonio Laguna-Camacho and Magda Chechlacz. All the other studies (Chapters 4 to 9) were conducted over the interactive website of the School's Research Participation Scheme (RPS, Sona Systems Ltd.). The RPS, supplemented by email, was used to seek volunteers and to carry out the questionnaire research entirely online. The registrants recruited were all students within the School of Psychology, earning Research Participation Credits required for their degree course.

Participants received concise information about the study including what they would be asked to do and report. They were informed that all their responses would be kept anonymous and that they would be identified only through the ID number assigned to them in the research website. It was also indicated to them that, on completion of the task of the study, they would receive participation credits. After this briefing, volunteers provided informed consent by agreeing to take part in the respective study. Once they began their participation, they were free to withdraw at any moment as indicated by an option on the screen of the online study. They were also free to contact the PhD student confidentially via email if they had any query or issue regarding the study.

PART B

CULTURALLY RECOGNISED PATTERNS OF EATING AND EXERCISE

CHAPTER 3
MEALS DESCRIBED AS HEALTHY OR UNHEALTHY

3.1 Introduction

3.1.1 Aim

This Chapter presents a small experiment that had multiple purposes relating to the basis of this distinctive approach in people's ability to use words to deal with the realities of everyday life (Chapter 2, section 2.2). First, a large difference in effect was sought between two single words – indeed, of just the two letters distinguishing "*un*healthy" from "healthy." Secondly, the effect was sought in words that participants generated spontaneously, rather than in fixed or quantitative responses or physical changes such as movement or food intake. Thirdly, this free narrative was tested for objectivity by comparison of its references to foods with a communal standard for healthy eating. If participants shared conceptions of what it is to eat healthily, this would support the theory that, in particular cases, different wordings represent the same reality, such as distinctive episodes of eating in ordinary life.

A fourth purpose, beyond the experiment itself, was to gather wordings of purported past eating occasions that could be used to update the descriptions of local eating patterns that have previously been tested for effects on weight (Blair *et al.*, 1989).

3.1.2 Approach

Volunteers were asked to describe in writing a meal that was either "healthy" or "unhealthy." The words elicited that referred to patterns of eating were then categorised for comparison with national guidelines for healthy eating.

3.1.3 Expected findings

It was predicted that the vocabulary used to describe the meal would differ between the conditions "healthy" and "unhealthy" and correspond well with the concepts of healthy eating on the Eatwell website of the UK Food Standards Agency (Table 3.1).

The foods mentioned were expected to be the same or in addition to those used as examples in the healthy or unhealthy eating patterns collated by Blair and colleagues (1989).

Table 3.1 UK Food Standards Agency's messages for healthy eating.

Try to eat
· plenty of fruit and vegetables
· plenty of bread, rice, potatoes, pasta and other starchy foods
· some milk and dairy foods
· some meat, fish, eggs, beans and other non-dairy sources of protein
· just a small amount of foods and drinks high in fat and/or sugar
Try to eat less salt
· no more than 6g a day
Drink plenty of water
· about 6 to 8 glasses of water, or other fluids, every day
Cut down alcohol
· women: up to 2 to 3 units a day
· men: up to 3 to 4 units a day

Source: http://www.eatwell.gov.uk/healthydiet; accessed on 15/05/2010.

3.2 Method

3.2.1 Participants

The participants were visitors to the School of Psychology during the Open Day at the University of Birmingham in 2008. The volunteers for this experiment were mostly prospective students or their accompanying parents or friends. A total of 42 people took part, including two students and one staff member of the University who helped pilot the questions. Participants categorised their age-group as "child" (5 female), "young person" (14 female and 6 male) or "adult" (11 female and 6 male). All participants spoke English as their first language.

3.2.2 Design

The study in this Chapter had an experimental design with comparisons between subjects. Each participant had a single interview session. No selection criteria were applied except that volunteers were British residents.

3.2.3 Procedure

Volunteers were recruited by two researchers (one male and one female) in a room displaying some of the research carried out in the School. The experiment was presented as *Research on healthy eating* through a notice on the investigators' table inviting people to take

part. Each investigator administered questionnaires to different attendees as they came to the table. The volunteers were asked the question: *Would you be willing to tell us about a time when you ate in an unhealthy way?* If the person seemed doubtful or did not say 'yes' immediately, the investigator offered the other option: *...or you may prefer to tell us about when you ate in a healthy way*. Volunteers who agreed to either of these options then described the respective occasion in writing.

3.2.4 Instrument

Participants responded in their own words to a sequence of question items that applied the principles of the Cognitive Interview (section 2.3.1) to support recall of the eating episode that they regarded as healthy or unhealthy. The first item asked the participant to describe the eating occasion. This item provided additional prompts to report the sort of occasion, the location, the number of people present and the *food and drink consumed* with rough quantities. The second item asked for the date and time of the episode (to distinguish an autobiographical memory from general knowledge; Tulving, 1972). The third and fourth items asked the participant for factors that she or he thought would make eating in that way again in the future more likely (3rd item) or less likely (4th). The responses to these last questions are included in Chapter 11 as data relevant to influences on a lapse from a change in behaviour; hence they are not presented in this Chapter.

3.2.5 Analysis

The difference from 50% in the proportion of participants to describe healthy eating rather than unhealthy eating was tested using Fisher's test of exact probabilities (FEP) with one-tailed *p* values. The difference between occasions of healthy and unhealthy eating in time from their occurrence to recall was inferred by Mann-Whitney *U* test of ranks.

The words describing an occasion were divided into the categories Food intake, Sort of occasion, Location and People present, corresponding to the CI prompts to recall (3.2.4). Within each of these categories, words that were regarded by the investigators as meaning the same were assigned to one conceptual subcategory. The number of times that each subcategory had been written was contrasted between *healthy* and *unhealthy* eating episodes using FEP with two-tailed *p* values.

In addition, the agreement of elicited food words and their health attributions with current UK Food Standards Agency's dietary guidelines (Table 3.1) was assessed by a member of the research team (AL-C) with a BSc degree in human nutrition.

3.3 Results

3.3.1 Choice to report *healthy* over *unhealthy* eating

A total of 61% of participants preferred not to report *unhealthy* eating, $p = 0.07$ (FEP; Table 3.2). A reliably higher proportion of adults and of females opted to describe *healthy* eating, $p < 0.0002$ and $p < 0.01$, but neither group difference in the proportion of younger participants or of males was reliable, $p = 0.34$ and $p = 0.56$.

Table 3.2 Counts of opting to describe *unhealthy* (UE) or *healthy* (HE) eating.

	Total		% shift from	Younger group		Older group	
	UE	HE	UE to HE	UE	HE	UE	HE
Total	16	26	61	12	14	4	12
Females	10	20	67	7	13	3	7
Males	6	6	50	5	1	1	5

3.3.2 Descriptions of *healthy* and *unhealthy* meals

The accounts of episodes of eating a *healthy* or *unhealthy* meal configured foods and the context of eating into a coherent whole. Descriptions of *healthy* meals included the following (each example being all of what was written).

I had cereal and fruit for breakfast.

Lunch time at college with friends. Cheese sandwich, brown bread, one apple, one glass of water.

Dinner with cousins at their home fruit, chapatti and vegetable soup.

The following are examples of descriptions of meals regarded as *unhealthy*.

Today at Avanti, two slices of onion & cheese pizza plus new potatoes, Coca Cola & Kit Kat.

About 3 days ago I missed lunch so I went to McDonalds in the afternoon, I had a BigMac burger and French fries, with my sister, 3:30 pm.

At an 18th birthday party. I ate buffet food such as pizza. I was with lots of friends. I drank some alcohol.

Overall, recorded occasions of eating healthily and unhealthily occurred about one day before their recall, *Mdn* = 0.95 days (quartiles 0.60, 2.0). No difference in recency from recall between occasions of healthy and unhealthy eating was found, *Mdn* = 0.85 days (0.5, 1.4) *vs*. *Mdn* = 1.05 days (0.60, 3.4), $U = 187$, $p <$ 0.6.

3.3.3 Conceptual differences between *healthy* and *unhealthy*

3.3.3.1 Relationships with current dietary guidance

The assignments of foods to *healthy* and *unhealthy* occasions were in line with the UK FSA's food guidance for intake of fruit and vegetables, foods high in fat and/or in sugar, water, food high in salt and alcohol a day (Table 3.3). For the other food guidelines, there was no evidence that mentions of the corresponding foods differed relatively between occasions of *healthy* and *unhealthy* eating (Table 3.3).

3.3.3.2 Subcategories of foods and drinks

The particular foods and drinks reported in each condition fell into 27 subcategories (Table 3.3). The subcategories Fruit, Salad/vegetables and Water appeared only in descriptions of *healthy* eating occasions. The subcategories Chocolate, Burger and chips, Pizza, Coke, Salt and Alcohol occurred only in occasions of *unhealthy* eating. Two other subcategories that included items from the starchy food group such as bread or potato and non-dairy sources of protein group such as meat or fish appeared more in occasions of *unhealthy* eating (Table 3.3). The other 16 subcategories did not differ in incidence between *unhealthy* and *healthy* meals (Table 3.3).

3.3.3.3 Sort of occasion

There were five subcategories of sort of occasion (Table 3.4). Three included meals that fell at conventional meal times – Breakfast, Lunch and Dinner/evening meal (Table 3.4). The incidences of Breakfast and Lunch did not differ reliably between *unhealthy* and *healthy* meals. The incidence of Dinner occasions was higher in *healthy* than in *unhealthy* eating (Table 3.4). Evening meals occurred at home. Relatives were mentioned in the accounts and so these were usually family occasions.

The fourth subcategory of sort of occasion was meals that took place out of the home, mostly not at the meal times that are usual in the UK. Participants did not use a particular term to name these meals. Meals out were mentioned more often in unhealthy eating occasions (Table 3.4).

The fifth subcategory comprised episodes Between meals, including what some reports called a "snack." The incidences of episodes Between meals were not reliably different between *unhealthy* and *healthy* eating (Table 3.4). Nevertheless, occasions Between meals in *unhealthy* eating included the three food and drink categories Chocolate, Biscuits and Coke, whereas Fruit such as apple and grapes were included in *healthy* eating.

Table 3.3 Counts of subcategories of food and drink ingested on reported occasions of unhealthy eating or healthy eating in groups listed by the Food Standards Agency, UK.

UK FSA food group	Subcategories of food and drink-reported	Unhealthy eating (foods=27)		Healthy eating (foods=80)		Same counts
		Count	%	Count	%	*p*
1. **Fruit and vegetables**	- [fresh] fruit, apple, grapes, pineapple, fruit juice	0	0	12	15	**0.02**
	- salad [with cheese and some pickles], vegetables, spinach	0	0	11	14	**0.03**
	- vegetable dish, vegetable stir fry, vegetarian casserole	0	0	3	4	0.41
	All subcategories	*0*	*0*	*26*	*33*	***0.01***
2. **Bread, rice, potatoes, pasta and other starchy foods**	- cereal, oat and porridge, Bran Flakes, muesli [with milk]	0	0	4	5	0.31
	- bread, bran bread, chapattis, toast [with raspberry], nutrigrain	0	0	7	9	0.12
	- pasta and pesto, cous cous, risotto [plus mushrooms]	0	0	3	4	0.41
	- potatoes, new potatoes, hash browns	1	4	2	3	0.84
	- [ham/ cheese] sandwich	0	0	2	3	0.56
	- pizza, burger and fries, [fish and] chips, crisps, [choc] biscuit	11	41	0	0	**0.01**
	All subcategories	*12*	*44*	*18*	*23*	*0.11*
3. **Meat, fish, eggs, beans and other non-dairy sources of protein**	- grilled fish, chicken breast, bacon, egg, sausages	1	4	6	8	0.47
	- beans, pulses, lentils	1	4	4	5	0.63
	- ham [sandwich]	0	0	1	1	0.75
	- burger [and fries], fish [and chips]	4	25	0	0	**0.01**
	- tofu	0	0	1	1	0.75
	All subcategories	*6*	*22*	*12*	*15*	*0.54*
4. **Milk and dairy foods**	- yogurt, low-fat yogurt, [Bran Flakes -] skimmed milk, [muesli with] milk, cheese [sandwich/pizza]	4	14	7	9	0.46
5. **Foods and drinks high in fat and/or sugar**	- bag of crisps	1	4	0	0	0.25
	- chocolate biscuit	1	4	0	0	0.25
	- fish and chips	2	7	0	0	0.06
	- [onion & cheese] pizza, regular pizza	3	11	0	0	**0.02**
	- [BigMac] burger and fries/chips	4	14	0	0	**0.01**
	- fizzy lemonade, Coca Cola, Diet Coke	4	14	0	0	**0.01**
	- bar of chocolate, chocolate Toblerone, Kit Kat	5	18	0	0	**0.01**
	All subcategories	*20*	*74*	*0*	*0*	***0.01***
6. **Food high in salt**	- cereal, soup, pasta, bread, pulses, bacon, sausages, crisps, pizza, burger and fries, fish and chips	13	48	14	18	**0.03**
7. **Water**	- glass of water, bottle of water, water	0	0	10	13	**0.04**
	- cup of tea, mug of tea, mug of coffee	1	4	4	5	0.63
	All subcategories	*1*	*4*	*14*	*18*	*0.12*
8. **Alcohol a day: ≤ 2-3 units women, 3-4 units men**	- one glass of white wine, two glasses of red wine	1	4	2	3	0.56
	- drink some alcohol, lots of alcohol, eight pints of beer	5	18	0	0	**0.01**
	All subcategories	*6*	*22*	*2*	*3*	***0.01***

p values for one-tailed Fisher's exact probability test

Table 3.4 Counts of sorts of context to occasions of unhealthy and healthy eating.

		Unhealthy eating (N = 16)		Healthy eating (N = 26)		Same counts
Subcategories	Context detail reported	Count	%	Count	%	p
Meal time						
Breakfast	breakfast	2	13	6	23	0.69
Lunch	lunch, workday lunch, lunch time	2	13	7	27	0.44
Evening/dinner	dinner, evening meal, family meal [evening], family meal, family occasion, formal ball	1	6	9	35	**0.02**
[between meals]	a snack, when I want to snack, break times	3	19	2	8	0.35
[meals mid-afternoon, night]	no occasion - just for fun [4:30 pm], miss lunch [3:30 pm], meal [3:00 pm], night out, out on Friday night, birthday party	8	50	2	8	**0.05**
Place						
Home	home, house	2	13	16	62	**0.01**
School/Work	collage, school, school canteen, Avanti, building, staff canteen	5	31	8	31	1.00
Out	McDonalds, Burger King, Pizza Hut, Silver Grill, kebab shop, cinema, birthday party, night out, Sudley castle [formal ball], meal out,	9	56	2	8	**0.01**
People present						
Alone	alone, on my own	2	13	6	23	0.69
One other	dad, wife, sister in law, son, daughter, cousins, family, whole family	2	13	4	15	1.00
Two or more	friends, work mates, country people	12	75	16	62	0.50
Relation						
Family members	-	1	6	11	42	**0.01**
Friends	-	13	81	9	35	**0.01**

p values for one-tailed Fisher's exact probability test

3.3.3.4 Location

The locations at which the described eating occasions took place could be subcategorised into Home, School or work and Out of the home (Table 3.4). Eating at home was a feature of occasions reported as *healthy* (Table 3.4). In contrast, eating out was a feature

of *unhealthy* eating. School or the workplace was equally divided between *unhealthy* and *healthy* eating (Table 3.4).

3.3.3.5 People present

The answers regarding people present fell into the three subcategories: eating Alone; With one other; With two or more. The number of people present in proportion to the total did not differ appreciably between *unhealthy* and *healthy* eating (Table 3.4). Eating with friends was characteristic of *unhealthy* meals, whereas eating with family characterised *healthy* meals (Table 3.4).

3.4 Discussion

This experiment met the aim of eliciting descriptions of unhealthy and healthy eating occasions carried out by British residents in free living conditions. The difference of just two letters between the words “unhealthy” and “healthy” had an enormous effect on the words that people wrote down. Comparisons with the nutritional concepts conveyed by the words in national dietary guidance showed that the participants’ words dealt with a communally recognised reality.

Furthermore, good performance at recognising specifics of nutritional science was shown by some perfect matches with that guidance. Such a finding is not unexpected because much of the guidance has been well disseminated in the British media, with support from labelling on food packs.

This success of the experiment (despite a modest number of participants) provides good support for the general approach in this Thesis of relying solely on the exchange of words (and verbally conceptualised numbers) to deal with the realities of weight control. The solid findings from the experimental design also provide good reason for using the data in other parts of the work as relevant.

Other emerging differences in sorts of food and context across healthy and unhealthy meals showed that localisation of specific patterns of eating is needed beyond the food groups suggested by nutritional guidelines. For this purpose, the foods and drinks most commonly regarded as healthy or unhealthy alongside their context can be used to confirm or expand the examples given in patterns of eating used by Blair and colleagues (1989), in wordings that were also elicited from people living in the English Midlands but 20 years earlier (Chapter 4). The findings can be taken also to support the investigators’ expectations of directions of change in frequency in eating patterns liable to affect weight that participants are likely to

wish to experiment with (Chapters 9 and 11) or to change without interacting with the research team (Chapter 8).

That the reported occurrence of occasions was dated within few days before the recall indicates that unhealthy and healthy eating occasions were commonly practised within this group.

Young women preferred to report mostly occasions of healthy eating which might indicate that this sub-group eat predominantly healthily. Alternatively, it is possible that they avoided reporting unhealthy eating in the face-to-face interview with researchers. To minimise this possible bias, anonymous participation is recommended in subsequent studies involving the self-reporting of eating occasions (Chapter 8 and 9).

Also, it is possible that participants reported recent eating occasions because they were more available in memory than remote events (2.1). This finding encourages the attempts to elicit valid information of people's most recent occasions of eating and exercise further examined in Chapters 5 and 6.

To substantiate these findings, a larger sample and a design involving a richer set of wordings for describing occasions of healthy and unhealthy eating. The sample should be from the population being investigated, in the rest of this Thesis, students of the University of Birmingham.

CHAPTER 4
STUDENTS' CATEGORISATION OF CUSTOMARY EATING AND DRINKING PATTERNS

4.1 Introduction

4.1.1 Aim

This research relies on participants using sets of words to refer to specific activities – common patterns of eating or exercise (Chapter 2, section 2.2). The aim of the experiment reported in this Chapter was to test the realism of such descriptions. The evidence for such objectivity was participants' consensus that different wordings denoted the same activity. That consensus could then be used to update and extend the wordings for patterns of eating that were used in previous work on weight reduction (Blair *et al*., 1989).

4.1.2 Approach

Participants judged the degree of dissimilarity between a standard wording and a test wording for patterns of eating. Consensus on meaning in common was measured as a group median that showed little dissimilarity. The two sets of wordings were developed from several sources, as follows.

Standard wordings. To maximise relevance to the present Thesis, the standard wordings about activities were derived from the public's accounts of practices of healthy eating that had already been investigated for their effects on weight by Blair and colleagues in English West Midlands (1989; see original descriptions in annexe to Chapter 4). Some of those practices were avoiding or doing less of an unhealthy eating practice. This experiment used factual descriptions and so those standard items were rewordings as specific patterns of healthy or unhealthy eating described without evaluative implications. For example, the standard wording "Eating snacks high in fat" was composed from the healthy practice "Eat few nuts, crisps or other high-fat snackfoods."

Test wordings. The test wordings were based on the accounts of actual meals labelled as *healthy* or *unhealthy* which were elicited among people from the same locality in the experiment reported in Chapter 3. Most of the test wordings were selected to represent the same concept as the standard. For example, for comparison with the standard wording "snacks high in fat," a description of the unhealthy meal was "I had two slices of onion & cheese pizza with new potatoes, Coca Cola and a Kit-Kat today at Avanti." A test item referring to a concept opposite to that in the standard item was included in each set of items, whether on

healthy or unhealthy patterns. The contrast was included to help ensure that participants carried out difference-rating task. The intuitive design of a set would be validated by the participants if they rated the contrasting test items as very different from standard.

4.1.3 Expected findings

The judged difference between the standard and each test item was predicted to be close to zero for wordings referring to the same nutritional concept or relation to mealtimes. A close to zero central tendency of a group's rated differences between a test item and the standard item would be evidence of a consensus in those participants' culture that the two wordings referred to the same pattern of behaviour.

A test item based on an opposite concept to the standard item was predicted to be rated as totally different from the standard. Such a finding consistently across participants would be evidence that the test item referred to a completely separate pattern of behaviour.

4.2 Method

4.2.1 Participants

A total of 25 psychology students of the University of Birmingham took part in the experiment. They were recruited through the website used for advertising research conducted in the School of Psychology. These students were white British females with a mean age of 20 years (SD = 3 y) and their first language was English.

4.2.2 Design

This experiment was designed for comparisons within subjects. Each participant had a single online session. No selection criteria were applied to the volunteers.

4.2.3 Procedure

The study was posted with the title *Eating patterns performed by others*. Students were informed that they would evaluate the extent to which real accounts of eating events were good or bad examples of different eating patterns. Enquirers who agreed to take part signed up to the experiment consisting of one questionnaire session online. One subset of participants answered questions about unhealthy eating patterns (QUE, N = 15); another subset worked on healthy eating patterns (QHE, N = 10). Available timeslots were posted apart for each type of questionnaire. Participants were not briefed about the version that they would complete nor the healthiness concepts attributed to eating patterns and occasions.

4.2.4 Instrument

The eating practices collated by Blair and collaborators (1989) were classified as healthy if the emphasis was on doing them more often or as unhealthy if the emphasis was doing them less often. Their reference to change in frequency was removed. For instance, "avoid sweet extras" was edited to the pattern *eat a sweet extra.* The original descriptions of the eating practices were edited to increase their usefulness for research into weight control. For example, the description of "eating fresh fruit and salad instead of higher-calorie food*"* was converted into two patterns, *eating fresh fruit* and *eating salad*, so that effects of the two patterns could be investigated separately.

Each standard pattern of eating adapted from Blair *et al.* (1989) was judged for difference from each of a subset of healthy or unhealthy test occasions. The QUE was comprised of 9 standard items with test items divided among them in 45 pairs. The QHE included 70 parings of test items with 11 standard items. Each standard item was paired with four to six test items. Some test items were repeated across the subsets with a standard item each. The sequences of standard and test items were randomised for each respondent.

The instructions on the difference-rating task were in the format, "How good is the following description as an example of the pattern of [*description of standard pattern*]*?"* followed by a test description of eating occasion. For example, a question in the QHE was: *How good is the following description as an example of the pattern of 'Eating food high in fibre'? - I had a cheese sandwich on brown bread, one apple and one glass of water for lunch at college with friends.* This test description was hypothesised to be judged as similar to the standard description in the occasion referred to. The judgment was one of the six options: *Perfect example* (scored as 0% different), *20% different*, *40% different*, *60% different*, *80% different* and *Totally different* (scored as 100% different).

4.2.5 Analysis

The scores for differences of test items from the standard item in each subset could not be normally distributed, because the difference score for the test item with a concept opposite to that of the standard was expected to be very high, while the low difference scores might form a J distribution, peaking at zero difference. Hence each subset was subjected to an analysis of ranks (Friedman's test). It was hypothesised that the group's median difference scores would vary reliably across the test items in each subset, particularly because of the high scoring 'opposite' item but possibly also because some test items more similar to the

standard might nevertheless be regarded consistently across the group as somewhat different from standard.

4.3 Results

4.3.1 Variation in difference of test from standard

The rated degree of difference between the standard item and each test item varied reliably in incidence within each set of wordings (Table 4.1).

A limited number of the test wordings were judged to be only 0-20% different from their standard wording. Most test items ranged from 20-60% different. The test item designed to be opposite in concept to the standard was nearly always rated 80-100% or 60-80% different.

This pattern of findings is well illustrated for the set of wordings with a standard centred on the phrase *low calorie food at meals* (Table 4.1, row HE3). An occasion referred to as consuming an *apple* and a *bottle of water*, and another occasion when *Bran Flakes with nuts* were eaten with *skimmed milk*, were each rated at a group median (and mode) of 0-20% different from that standard. This showed that such materials were generally regarded by these participants as low-calorie foods.

The designed opposite concept of *risotto* with *mushrooms*, *smoked bacon* and *red wine* had a median rating of 80-100% different from *low calorie food at meals*. That fulfilled the expectation that such foods were not regarded as low in calories.

The test item that included the words *ham sandwich, Nutrigrain bar* and *bunch of grapes* was rated as 30-50% different. Presumably the grapes were regarded as a low-calorie food, whereas a ham sandwich and perhaps a Nutrigrain brand of snack bar would be perceived as high in calories, decreasing the overall similarity to *low-calorie food*. However these are *post-hoc* explanations of the equivocal finding. Only a near-zero perceived difference shows that all the behaviour denoted by the words is the same as that meant by the standard wording. Hence the median 0-20% ratings are presented as the primary findings.

4.3.2 Consensus on wordings for food or drink consumed on occasions of healthy eating

Test items containing the word *fruit* were indistinguishable (median rating at the 0-20% category) from the standard descriptions *low fat food* (Table 4.1, HE1), *low-calorie food at meals* (HE3) and, trivially, *fresh fruit* (HE6). The term *vegetables* performed in the same way, as being minimally different from *low fat food* (HE1), *salad* (HE7) and of course *vegetables* itself (HE8). The test descriptions that included the term *water* were also rated as 0-20% different from the standard *low calorie drinks at meals* (Table 4.1, HE4).

Table 4.1 Rated differences between standard and test descriptions (key wordings only) of patterns of healthy (HE) and unhealthy (UE) eating. The occasions are listed in order of their median rated difference from the eating pattern. Occasions having the same superscript were tested on two or more patterns. Words in bold = wordings predicted to be similar to the pattern. *[contrast Xn]* = Hypothesised to be an eating occasion unrelated to the pattern.

Code	Standard	Median rated difference of test wording from standard wording of a description of an eating pattern			Variation among medians	
		0 - 20% different	30 - 50% different	60 - 100% different	χ^2	$p <$
HE1	***low-fat food***	**apple**, bottle of water[a] **salad**, potatoes, lentils, water[b] pot of **salad**[c] Bran Flakes w/nuts and skimmed-milk[d] boiled **vegetables**, fresh soup, bread[e]	toast with raspberry jam, glass of water[i] ham sandwich, Nutrigrain bar, **bunch of grapes**[q]	[risotto plus mushrooms, smoked bacon, red wine][t]	27.9	0.0001
HE2	***low-fat drink***		Bran Flakes w/nuts and skimmed-milk[d]	[chocolate biscuit, can of Diet Coke][l] hash brown, beans, toast & tea[v] [onion & cheese pizza plus new potatoes, Coca Cola, Kit Kat][m]	1.8	0.6
HE3	***low-calorie food at meals***	**apple**, bottle of water[a] Bran Flakes w/nuts and skimmed-milk[d]	pasta and pesto, **salad**, fruit juice[h] green **salad** starter plus oil: balsamic vinegar, chicken breast, cous cous, fresh **fruit** salad, glass of white wine, mug of coffee[s] ham sandwich, Nutrigrain bar, **bunch of grapes**[q]	[risotto plus mushrooms, smoked bacon, red wine][t]	27.5	0.001
HE4	***low calorie drinks at meals***	apple, **bottle of water**[a] pasta and pesto, salad, **fruit juice**[h]	cup of tea, bar of chocolate[i] muesli with milk, mug of tea[f] risotto plus mushrooms**,** smoked bacon, red wine[t]	soup, vegetable stir-fry, mushrooms, fruit, water[u] chocolate biscuit, can of Diet Coke[l] as snack hash brown, beans, toast & tea[v] [regular pizza, fizzy lemonade][o] [onion & cheese pizza plus new potatoes, Coca Cola, Kit Kat][m]	28.2	0.0001
HE5	***food or drink labelled 'low-calorie'***	Bran Flakes w/nuts and skimmed-milk[d]	apple**, bottle of water**[a] chocolate biscuit, can of Diet Coke[l] green salad starter plus oil: balsamic vinegar, chicken breast, cous cous, fresh fruit salad, glass of white wine, mug coffee[s]	[risotto plus mushrooms, smoked bacon, red wine][t]	12.3	0.02
HE6	***fresh fruit***	fish, **fruit**, salad, water[j] home made soup, low fat yoghurt , **bunch grapes**		pasta and pesto, salad, fruit juice[h] [toast with raspberry jam, glass of water][i]	21.0	0.0001

Table 4.1 (continuation)

HE7	***salad***	**boiled vegetables**, fresh soup, bread[e]	soup, **vegetable stir-fry**, mushrooms, fruit, water[u] **vegetarian casserole** w/pulses, tofu, **vegetables**, water[g]	[onion & cheese pizza plus new potatoes, Coca Cola, Kit Kat][m]	15.3	0.004
HE8	***vegetables***	**salad**, potatoes, lentils, water[b]	**vegetarian casserole** w/pulses, tofu, **vegetables**, water[g]	risotto plus mushrooms, smoked bacon, red wine[t] hash brown, beans, toast & tea[v] [slices of onion & cheese pizza plus new potatoes, Coca Cola, Kit Kat][m] [fish and chips] [BigMac burger and French fries][n] [bag of crisps, bar of chocolate, no drink][k]	51.8	0.0001
HE9	***high-fibre food***	**oat and bran porridge**, glass of water vegetarian casserole with **pulses**, tofu, vegetable**s**, water[g] salad, potatoes, **lentils**, water[b]	cheese sandwich, **brown bread**, apple, water[r] fish, fruit, salad, water[j]	hash brown, **beans**, toast & tea[v] pot of salad[c]	24.5	0.0001
HE10	***small amounts of starch***	**toast** with raspberry jam, glass of water[i]	boiled vegetables, fresh soup, **bread**[e] muesli with milk, mug of tea[f] [chocolate biscuit, can of Diet Coke][l]	salad, potatoes, lentils, water[b] pasta and pesto, salad, fruit juice[h] cheese sandwich, brown bread, apple, water[r] ham sandwich, Nutrigrain bar, bunch of grapes[q] hash brown, beans, toast & tea[v] [onion & cheese pizza plus new potatoes, Coca Cola, Kit Kat][m] [fish and chips, no drink][p] [BigMac burger and French fries][n]	39.5	0.0001
HE11	***polyunsaturates***		fish, fruit, salad, water[j] [fish and chips, no drink][p]		0.0	1.0
UE1	***fried food***	BigMac burger and **French fries**[n] **fish and chips**, no drink[p]	regular pizza, fizzy lemonade[o] **bag of crisps**, bar of chocolate, no drink[k]		17.8	0.0001
UE2	***fatty meat***	**BigMac burger** and French fries[n]		fish and chips, no drink[p] risotto plus mushrooms, smoked bacon, red wine[t] ham sandwich, Nutrigrain bar, bunch of grapes[q] [green salad starter plus oil: balsamic vinegar, chicken breast, cous cous, fresh fruit salad, glass of white wine, mug coffee][s] [vegetarian casserole w/pulses, tofu, vegetables, water][g]	45.2	0.0001

Table 4.1 (continuation)

UE3	***fat in meals that could have been removed***	**BigMac burger** and French fries[n] **regular pizza**, fizzy lemonade[o]	lots of buffet food and drank lots **fish and chips**, no drink[p]		5.1	0.2
UE4	***high fat snacks***	**bag of crisps, bar of chocolate**, no drink[k] **chocolate biscuit**, can of Diet Coke[l] onion & cheese pizza plus new potatoes, Coca Cola, **Kit Kat**[m]		[ham sandwich, Nutrigrain bar, bunch of grapes][q]	21.1	0.0001
UE5	***sweet extra***	cup of tea, **bar of chocolate**[i] bag of criss, **bar of chocolate**, no drink[k]		toast with raspberry jam, glass of water[i] [apple, bottle of water] [a]	35.6	0.0001
UE6	***sugary food***	**chocolate biscuit**, can of Diet Coke[l]		[toast with raspberry jam, glass of water] [i] hash brown, beans, toast & tea[v] [ham sandwich, Nutrigrain bar, bunch of grapes][q] [pasta and pesto, salad, fruit juice] [h]	26.6	0.0001
UE7	***food between meals***	cup of tea, **bar of chocolate**[i] as snack	bag of crisps, bar of chocolate, no drink[k] for breakfast BigMac burger and French fries[n]	onion & cheese pizza plus new potatoes, Coca Cola, **Kit Kat**[m] ham sandwich, Nutrigrain bar, bunch of grapes[q] for lunch cheese sandwich, brown bread, apple, water[r] apple, bottle of water [a] for lunch	33.9	0.0001
UE8	***calories in a drink between meals***	regular pizza, **fizzy lemonade**[o] buffet food: pizza, **drank some alcohol**	chocolate biscuit, can of Diet Coke[l] as snack	cup of tea, bar of chocolate[i] as snack [soup, vegetable stir-fry, mushrooms, fruit, water][u] [apple, bottle of water][a] for lunch	22.9	0.001
UE9	***alcohol***		risotto plus mushrooms, smoked bacon, red wine[t] [soup, vegetable stir-fry, mushrooms, fruit, water, shorts][u]	green salad starter plus oil: balsamic vinegar, chicken breast, cous cous, fresh fruit salad, glass of white wine, mug coffee[s] [ham sandwich, Nutrigrain bar, bunch of grapes][q]	25.2	0.0001

4.3.3 Consensus on wordings for foods in unhealthy eating

Meals that included *burger & fries* or *fish & chips* were categorised with *fried food* (Table 4.1, standard item UE1). More specifically, *burger* was recognised as *fatty meat* (UE2). Occasions that included *crisps* or a *chocolate bar*, were classified as *high fat snacks* (UE4). A *chocolate bar*, as well as a *chocolate biscuit,* was also recognised as an example of a *sugary food* (UE6) as well as of a nutritionally non-specific *sweet extra* (UE5).

4.3.4 Consensus on wordings for timing relative to meal

Occasions referred to by test wordings that included *bar of chocolate as snack* (Table 4.1, UE7) or *drank some alcohol at a birthday party* (UE8) were recognised as patterns of behaviour that could be described as *food between meals* or *calories in a drink between meals* (median 0-20% different).

4.3.5 Consensus on wordings for eating patterns distinct from the standard

Wordings previously elicited for healthy meals (Chapter 3, section 3.3.2) proved to be perceived by the participants in this experiment as referring to foods or drink distinct from those implied by their standard item's wording as an example of unhealthy eating (rated difference of 80-100%). Thus *fruit* was involved in behaviour perceived to be completely distinct from the eating of *fatty meat* (Table 4.1, UE2), *high fat snacks* (UE4), *a sweet extra* (UE5) and *sugary food* (UE6). *Vegetables* in a meal also distinguished it sharply from one containing *fatty meat* (UE2).

The test wording of *food high in sugar* was 80-100% different from the standard wording *fresh fruit* (Table 4.1, HE6). Presumably the high 'natural' sugar content of ripe fruit was regarded as healthy, whereas the sugar added to a product during manufacture was reckoned to be unhealthy.

Unsurprisingly, but helping to validate the method, a *food high in fat* was totally different from *low fat food* (HE1) and also from *salad* (HE7) and *vegetables* (HE8). Similarly, the tested occasions that included *drinks high in sugar* or *alcohol* were perceived as completely distinct from the standard occasion, *low calorie drinks at meals* (HE4).

An influence of words as distinct from nutritional concepts was found in a median 80-100% difference between *low calorie drinks at meals* and *Diet Coke as snack* (Table 4.1, HE4). A purely verbal distinction could also account for the median 80-100% difference between the standard wordings *food between meals* or *calories in a drink between meals* and a reference in the test item to a meal such as breakfast, lunch or evening meal.

4.4 Discussion

The test wordings from Chapter 3 that were expected to refer to similar activities to a standard wording from Blair *et al.* (1989) were rated less dissimilar to the standard than was the test wording that was expected to contrast. This distinction was observed for 17 out of the 20 standard wordings, 9 about healthy eating and 8 of unhealthy. That is, consensus wordings of patterns of eating can readily be established, despite the complexity of food items involved.

Furthermore, the median dissimilarity ratings followed the overlaps and disparities in wordings and nutritional concepts designed by the investigator. That is, the investigator's assumptions about the participants' knowledge of nutrition were well borne out, as in Chapter 3 (3.3.3). Therefore a research team that includes a nutritionist and members of the same culture as the research participants should be capable of designing wordings for descriptions of eating patterns to be used in communication within studies like the tracking of behaviour in this project (Chapters 8-11). This capability has been assumed by previous investigators but this experiment provided the first scientific evidence on that question. Furthermore these particular data are valid for use in measurements in this current student population

These findings also carry a number of detailed implications for the work in later Chapters of this Thesis. The first concern was that the available wordings of local practices were collected in the later 1980s from the general adult population, mostly older than students. Would they be applicable in the late 2000s, and to the student age range? The general wordings were found to be remarkably robust. The main differences were in the examples of foods involved: some extra items might be needed and some dropped, presumably because of changes in popularity. For example, neither *fish, salad, fruit* and water nor *fish and chips* were meals perceived as good example of *eating food high in polyunsaturates*. In such case, either the fish was not regarded as a source of polyunsaturates or such nutritional concept was not clearly recognised by participants.

The use of nutritional concepts could be relatively subtle. For instance, reports of meals that mentioned use of vegetables or fruit in a pattern of eating were rated as similar to a pattern of eating low-fat meals. That provides opportunities presenting reduction of fat intake as increase in use of attractive. However, it could create problems for the design and analysis of measurement of the effects of change in particular habits. For example, participants might report meals that included vegetables or fruit as low-fat meals. This could produce double counting and misleading co-variations. More generally, the perceived similarities of eating occasions denoted by distinct wordings as the same pattern of eating have important implications for the measurement of effects of changes in behaviour on weight. For example,

a change in reported frequency of a named habit might be because the participant is changing another pattern of behaviour.

Of course, it would be desirable to widen the range of eating patterns sampled. It would be important to include any prevalent patterns not covered by the questions used by Blair *et al.* (1989), such as those inferred from meals reported by participants in Chapter 3 (Table 3.3) or that may emerge from findings with larger samples. In addition, consensus on wordings for patterns of exercise or sitting needs to be determined.

Finally, the direction in which someone wishes to change a pattern of eating or exercise could well be determined by a desire to improve health. Hence the concurrence among various wordings and with the UK government's messages of healthy eating (Table 3.1) can be used to predict a participant's desired direction of change in frequency before or after options are presented (Chapters 8 and 9). How much they wish to change and how great a change are additional issues. Do more of a healthy habit may be more attractive than doing less of an unhealthy habit. This could be a matter of the framing of communications about healthy behaviour, with positive language being more motivating than negative language. Alternatively or as well, starting a new habit may be regarded as easier than stopping an old one.

PART C

ACCURACY OF THE TIMING OF AN OCCASION OF EATING OR EXERCISE

CHAPTER 5
DIFFERENCES IN REPORTED TIMING BETWEEN PAST OCCASIONS RECALLED BACKWARDS AND FORWARDS IN TIME

5.1 Introduction

5.1.1 Aim of this Chapter

In this research, the frequency of a described pattern of eating or exercise is estimated as the reciprocal of the difference between the recalled timings of each of its two most recent occurrences (2.3.2). Thus, these estimates of frequency rely ultimately on how well the timings of occasions of that eating or exercise habit are recalled and reported. The experiments in this Chapter and the next investigated the accuracy of such reported timings of autobiographical events.

5.1.2 Approach

The experiment reported in this Chapter measured accuracy as the difference between successive recalls of the times at which an activity occurred. The participant recalled a continuous sequence of activities twice, reporting the timing of each activity just before starting to recall another activity. The past sequence was reported once by starting with the most recent activity, moving on to the activity immediately preceding and so on (recalling 'backwards'). The other report was from the least recent activity to the most recent activity through the sequence over an overlapping period of time (recall 'forwards'). Forward and backward recalls were carried out for periods of both the previous day and also two days beforehand (Table 5.1). In order to balance the direction of recall and the one or two days beforehand across the sampled periods of the day, participants were pseudo-randomly assigned to one period under the four conditions specified in Table 5.1.

To facilitate accurate retrieval of the timing of an activity, the time of the event was requested after eliciting other details of the occasion. Hence in recall forwards, the time requested was the ending of the activity, whereas in recall backwards it was the starting time. The end of an activity and the start of the next activity should coincide in a switch-over event (Figure 5.1). Therefore the recalled time of the start of an activity in forward recall was estimated using the end time of the preceding activity. The difference between these two start times for an occasion of an activity measured the total error in reporting its timing. Contributing errors could arise from either or both the time recalled backwards or/and the starting time inferred from forward recall of the ending time of the previous activity.

Table 5.1 The 2 × 2 within-subjects design across periods of the day: recall backwards or recall forwards crossed with recall of activities one or two days beforehand.

Condition	Target times	Balanced sequence			
		1st Activities one day before		*2nd Activities two days before*	
Morning	Get up-12:30	1st Backwards	2nd Forwards	1st Backwards	2nd Forwards
Afternoon	12:30-16.30	1st Forwards	2nd Backwards	1st Forwards	2nd Backwards
		1st Activities two days before		*2nd Activities one day before*	
Evening	16:30-20:30	1st Backwards	2nd Forwards	1st Backwards	2nd Forwards
Night	20:30-Go bed	1st Forwards	2nd Backwards	1st Forwards	2nd Backwards

5.1.3 Expected findings

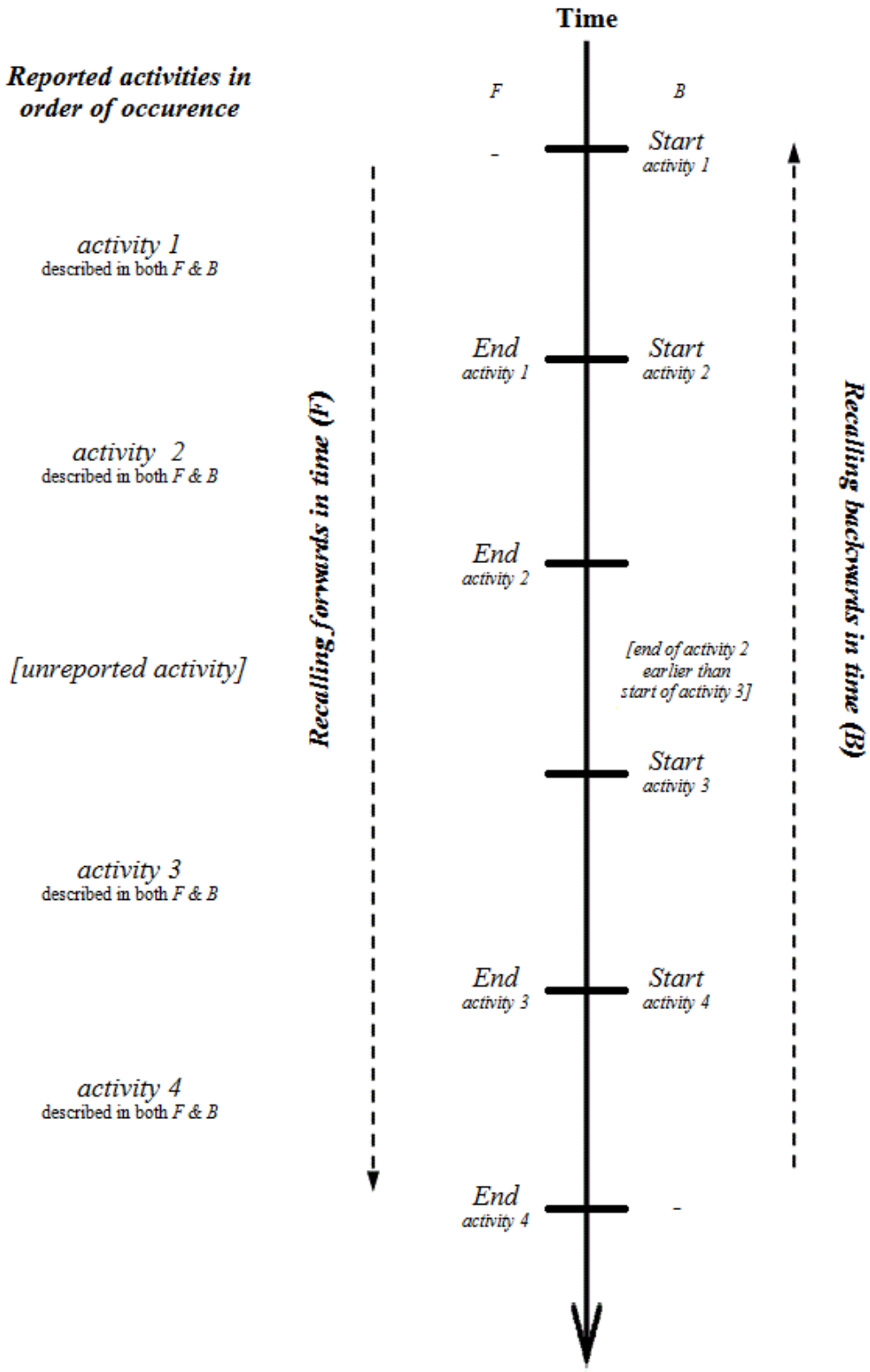
5.1.3.1 Single-cause ranges of differences in reported times

Since the observed disparities in timing could have arisen from a variety of inaccuracies in a reported time, the first objective was to seek evidence that there were distinct sources of error in timing. Different types of error might occur within different ranges of the difference in timings.

According to the 18th-century mathematician Siméon Denis Poisson, distinct sources of random variation in a quantity are distributed on different exponential functions of the declining cumulative probability of a case at a value (a 'survival' function). Since the logarithm of an exponential is a straight line, with the slope being its exponent, a change in slope between two linear regions of log probability distribution is evidence of two distinct random processes contributing to the decline in incidence. Hence the number of these intersecting straight lines or 'broken sticks' (Booth & Pain, 1970; Slater & Lester, 1982) in the function is a count of the types of error that are producing the observed cases. It is also possible for a 'stick' (linear region) to cross over another 'stick.'

On the other hand, where a region of the distribution is not dominated by a particular cause of error, then the function will be smoothly rounded in shape over that range of the observed quantity. Each time-difference range for a distinct type of error was expected to be identifiable with some aspect of the procedure for reporting timings. The source of error most relevant to accuracy of recall would be the experimentally manipulated periods of time since the reported event. However, any other possible sources of error need to be identified. Indeed, these other errors might be sensitive to the delay between the event and the report.

Figure 5.1 Double recall of times of an activity with example of unreported events between described activities.



5.1.3.2 Hypothesised sources of variation

Unreported events between activities. A difference between the reported timings of a switch-over from one activity to the next could arise when an event occurred between successive activities that participants did not consider that they should report, e.g. because it was very brief or obviously entailed by that shift between the reported activities (Figure 5.1). In that case, the reported time of the end of the activity would be some period earlier than the start of the next activity. The time of ending of one activity is used to estimate the start of the next activity in a forward recall sequence. Hence if the timing of an activity is observed to be earlier in forward recall than in backward recall, that error could have arisen from an unreported event between activities.

Conversely, so long as the two activities do not overlap in time, the start of an activity cannot be earlier than the end of the previous activity. Any time differences in that direction have to reflect other sources of error, such as in the recall itself of one or both of the timings. If such an error affects the two timings equally, then it will have the same incidence when the start of the activity is later than the end of the previous activity. Hence, the distribution of timing differences with backward earlier than forward recall should be subtracted from the distribution of differences in the opposite direction in order to estimate error from unreported events.

Mis-keyed time digits. Wrong keyboard entries of the recalled time of an activity would produce disparities between recorded times. This miskeying could be of any of the four digits of the minutes and hours of the time of day, the two digits of the day in the month and the last two digits of the year.

In the standard arrangement of number keys from 1 through 9 to 0, the most likely mis-hitting of a key is on the key on one or other side of that key. Miskeying of 0 or 1, however, can only produce a numerical error on one side (9 or 2 respectively)

Other sorts of miskeying of a numeral are conceivable but can hardly be mis-hits. Hence larger single-digit errors not attributable to strategies such as rounding may arise from confusion in recall, in this case either during response production or in differential recognition of the applicable number key. These recognition errors are liable to be susceptible to effects of delay since the event.

Rounding of a reported time. One strategy for economising on mental effort when reporting times of occurrence of an activity might be to approximate the actual time to a simple fraction of the hour or the nearest whole hour. For instance, the times of events that occurred at the minutes :50 or :10 of an hour might be reported as rounded to the minute :00,

i.e. the whole hour. Error from rounding to the hour is evident if one of the two timings is on the hour and the other timing is closer to that hour than to the preceding or following hour.

Other expected ranges of rounding were to the half hour and the quarter and three-quarter hours, to exact 10-minute times other than :30 and :60, and to the remaining 5-minute times marked on many clock dials. In addition, rounding might depend on direction of recall. For instance, if rounded times were more common in forward recall, that observation could indicate more rounding of times at the end of an activity.

Nevertheless it should be noted that, if everybody used the same rounding strategy all the time, there cannot be any errors of that sort to investigate.

The hypothesis of an active strategy of rounding in reporting a time must be distinguished from the idea of difficulty in reconstructing the exact time during recall. For example, it might be that the time seen on a watch or clock can be remembered for some hours or days but only an approximate time can be reconstructed after longer delays, perhaps using knowledge of habitual timings or of the times of related events. Hence reports with rounded times may be more common after two days than after one day.

Similarly for the sequence of recalls, if a multiple of a fraction of the hour was more common in the first recall than in the second recall, the increased precision in reporting the activity's time could be an effect of practice. Alternatively, if the multiple of fraction of the hour was more often in the second recall, this could be effect of reduced attention during reporting. It should be noted that the hypothesis is specific to the observed direction of difference.

Error from delay of recall. A longer interval between the occurrence of an activity and its recall could increase error through confusions among the greater number of activities that occurred during the delay. Therefore, the incidence and distribution of sizes of the timing differences identified with each source of error was contrasted between the experimentally designed periods of one and two days before recall.

If a Poisson-linear region ('stick') of differences in timing remained without an identified source of error but showed an increased in incidence or size of differences with increase in delay, that finding would indicate some inaccuracy in recall which is not analysed by this task.

Sort of activity. Some categories of activity (eating, exercise or whatever else is done over the recalled period) might be more liable than others to one or more of the above identified sources of difference in recorded times. Thus, the incidence of each difference in timings for each sort of activity was tested for reliable variation across categories of activity.

5.1.3.3 Open-ended descriptions of eating and exercise

The freely worded recall of a succession of activities was expected to provide a resource of descriptions of common patterns of eating and drinking and of movement and stillness among the sampled population, for use in subsequent research.

5.2 Method

5.2.1 Participants

A total of 40 psychology students from the University of Birmingham took part in this experiment by signing up on the research participation website of the School of Psychology (RPS, Sona Systems Ltd.). The experiment was posted with the title *How good is your episodic memory?* Volunteers were told that the task would be to remember everyday activities that they carried out recently. The participants were all British women with an age mean of 21 years (SD = 2 y) who spoke English as their first language. They were informed that their responses would be kept anonymous and that they would be identified only through an ID number. Participants gained partial credits toward their degree course requirement of taking part in research in the School. The study was conducted under the supervision of academic psychologists in the School of Psychology.

5.2.2. Design

The study in this Chapter had an experimental design with comparisons within subjects. The study was completed by each student in a single online session. No selection criteria were applied in recruiting the sample.

5.2.3 Instrument

Four versions of a questionnaire, one for each condition, were posted on the RPS website, available to 10 participants each. Each condition covered one out of four periods of the day to be recalled, from getting up in the morning to going to bed at night (Table 5.1). To predict the number of events over a specified period of the day, the mean duration of an activity (60 min) was taken from a similar study on recall of everyday activities run in the same population of students (not presented in this Thesis). That study also showed that, in one recall session, students reported up to 18 activities from the previous day with their timings. On this basis, each of the four periods of the day was covered by questioning on four successive activities. Thus, with four recall periods in each condition, each participant was asked to recall about 16 activities.

The questionnaire had four sections, one section each for backward and forward recall of activities carried out one day before and the same two sections repeated for backward and forward recall of activities carried out two days before.

The opening item of each series of recalls asked the participant to describe what she was doing at the particular time of the day specific to each condition.

So that participants would not correct or copy answers between the recall forwards and the recall backwards, these two sequences were presented separately and there was no option of going back once each sequence had been completed. A pair of questions was repeated cyclically to elicit the consecutive set of four activities in each recalled period. The first question elicited a description of the activity and the next question asked for its time of occurrence.

The questions in recall backwards asked for the next activity and time when it started and in recall forwards asked for the previous activity and time when it ended. The principles of the Cognitive Interview (2.3.1) were applied: for each activity, the participant was asked to report location, people present and "things" interacted with. To enhance the detail of the event, the first item also provided examples of objects taken from descriptions of activities engaged in the same period of day reported by the same population of students in the other experiment not reported in this Thesis. For instance, examples of objects in the afternoon condition were: computer, foods, the bus, a TV.

5.2.4 Analysis of data

5.2.4.1 Activities described in forwards and backwards recall

An activity recalled forwards was considered also to have been recalled backwards if both descriptions agreed in their type, location, other people present and objects reported. The descriptions of activities were sorted into mutually exclusive categories. The principle of this classification was similarity between accounts in the wordings for salient features of the event described.

5.2.4.2 Ranges of random variation in time differences

Peaks of incidence. A single source of random error in timings should produce a normal distribution of counts of each difference between activities' timings over a range of timing-differences that was dominated by that error. Hence the first step in analysis was inspection of histograms of the differences in timing for multiple modes and an attempt to fit each mode to a normal distribution, i.e. the Gaussian bell shape.

The outcome of this subjective graphic procedure was compared with the results of the objective quantitative procedure of Poisson's analysis, based on linear regions in the survival function (5.1.3.1).

Estimation of Poisson exponents. The proportional decreases in total counts of differences between timings of occasions were calculated from smallest to largest time-differences. The proportion at each value of time difference is the probability of observing a larger value. This calculation gives a negative exponential function, the logarithm of which is linear. If the line changes in the slope, that is a change in the exponent of the function. A succession of straight lines ('broken sticks') indicates ranges in the distribution of time differences coming from different sorts of random error process (5.1.3.1). The fit of the data onto a straight line was measured by least-squares regression. The ends of each straight line (its range) were determined by extending and contracting the series of timing-differences included in the regression until the r^2 value decreased (less variance was accounted for, even by increasing the amount of data).

5.2.4.3 Testing Poisson-linear ranges for identity with hypothesised sources of error

A range of observed differences between timings was inferred for each source of error considered (5.1.3.2). For example, the minimum difference for mis-hitting a number key is 1 (in time-units dependent on the digit, i.e. units or tens of minutes, hours or days of the month, or year or decade). The observed Poisson-linear ranges were then inspected for cases of coincidence between hypothesis and observation, e.g. differences of one unit either for mis-hits of key 2 to 9, or one value being an exact hour and the other value being less than 30 minutes from it. The incidence of cases in the hypothesised range within the candidate stick was compared with the incidence outside that stick by one-tailed χ^2 test against the remainder of the total incidences.

5.3 Results

5.3.1 Identification of events recalled in each direction

There were in total 320 forward recalls and 320 backward recalls. All the 640 reported activities fell into one of 17 categories of eating/drinking, movement or stillness (Table 5.2). Within the periods of the day for which recalls forwards and backwards overlapped, 110 pairs of reported wordings of activities appeared to be of the same occasion.

5.3.2 Errors in timing

Nearly half (46%; 51 cases) of these twice-recalled events of eating or exercise were given the same time in each sequence of recall. In the 59 observed cases of a difference in recalled time, the commonest disparities were the smallest in this experiment, i.e. 15 and 30 minutes (Figure 5.2). This is consistent with an exponential decline in size of difference in timing, as would be expected of random errors. However, the distribution of time-differences was uneven. The incidences of the differences appeared to bunch into four distinct ranges. Furthermore, each range appeared to fit a normal distribution (Figure 5.2).

5.3.3 Sources of errors in timing in the lowest ranges

When this distribution of differences in recalled timing of an eating or exercise occasion was subjected to Poisson's analysis, it proved to form an uninterrupted series of discrete exponentials, including two crossing the lower of two wide ranges (Figure 5.3).

The range of each Poisson line corresponded to one of the four normally distributed modes of time-difference in Figure 5.2. Hence there were four distinct sources of random error in the process of recalling and reporting a time of the start or finish of one of these occasions of eating or exercise. The incidences of the hypothesised ranges of errors in the observed ranges were high relative to the incidences in the rest of the data.

5.3.3.1 Unreported activities

The lower main Poisson-linear range (from 5 to 75 min, Figure 5.3, Table 5.3) had a numerically larger incidence of activities with a timing earlier than that of the subsequent activity than of activities later than the next activity's, variation among ranges χ^2 (1) = 27.8, $p < 0.0001$.

This excess of 37 earlier differences (from a total of 110: section 5.3.1) is evidence that one or more activities occurred between those pairs of reportedly successive activities. These omissions occurred with about 5% of the total number of reported activities (5.3.1). These unreported activities may have lasted from less than 5 minutes (the most precise time reported) to more than an hour, although such large differences may have involved other sources of error (see below).

Table 5.2 Categories of described activities.

Category	Examples of reported activities
Eating [and drinking]	
Breakfast	"had a coffee ... preparing breakfast"
Lunch	"was home entertaining a friend over lunch and tea etc."
Dinner	"eating dinner ... drinking Pepsi from cans"
Between meals	"ate a chocolate bar"
Alcohol	"went to Indi bar ... drank vodka and coke"
Moving	
Walk	"walked from the park to our house"
Get ready	"got ready ... wore a new HnM shirt dress thing"
Housework	"put a load of laundry in the machine ... did the washing up"
Exercise	"went to the gym"
Clubbing	"went to loaf bar ... danced"
Stillness	
TV	"... watched 'the world's shortest man' on TV!"
Coursework	"sat in Selly Park revising for exam"
Use car/train/taxi	"went to the McDonalds drive thru"
Talk to friends/family	"I came home ... interacted with my housemate"
Use computer	"was on my laptop ... surfing the internet"
Sleep	"taking some nap"
Phone	"talked … on the phone"

Figure 5.2 Differences between reported times of activities fitted to normal distribution curves over identified ranges of variation.

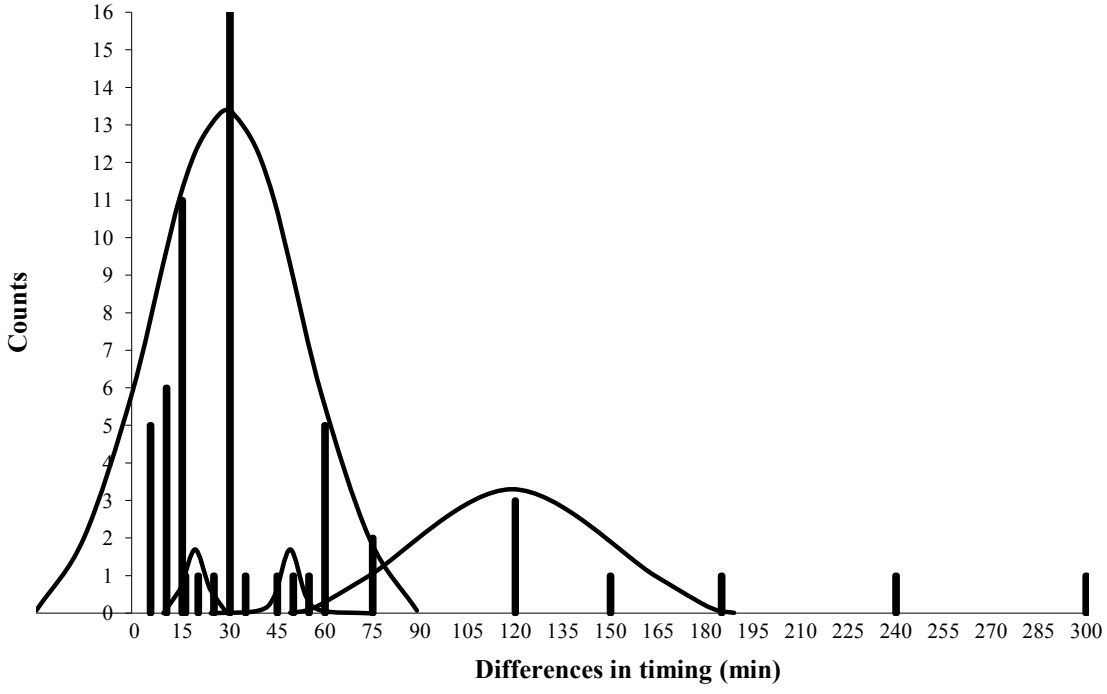


Figure 5.3 Four discrete sources of error in timing identified by adjacent or crossing exponentials in Poisson analysis. Each straight line is labelled with the range of best fit to linear regression, the equation of that line and the variance accounted for. The end of a line's range is marked by an enlarged data-point.

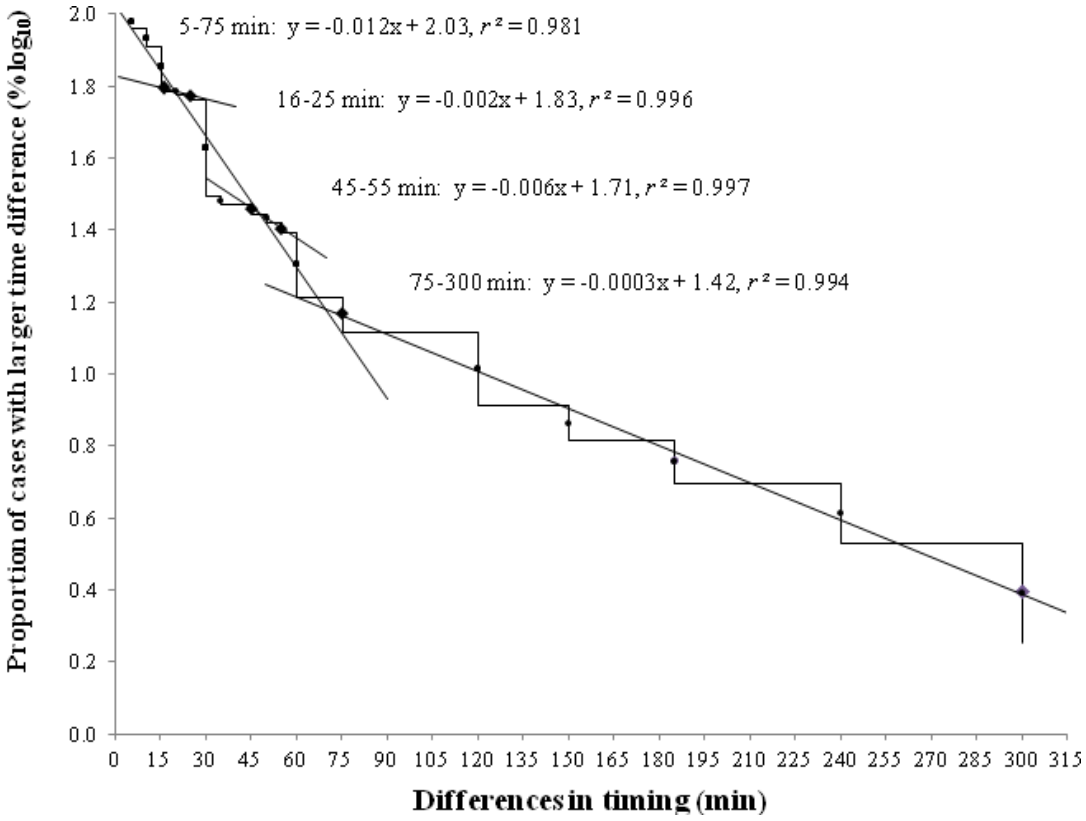


Table 5.3 Incidences in the Poisson-linear range of 5 minutes to 75 minutes of difference in reported timings where the ending time (in recall forwards) was either earlier or later than the start time (in recall backwards) of the next activity.

			time earlier than start	time later than start
		k	%	%
1	Total	52	87	13
2	Sort of habit			
3	*Eating*	11	81	18
4	*Movement*	13	92	8
5	*Stillness*	28	86	14
6	Delay			
7	*Day 1*	28	89	11
8	*Day 2*	24	83	17

5.3.3.2 Miskeyed time digits

All timings were reported in multiples of 5 minutes and so the differences between forward and backward recalls were also 5-min multiples and there were no miskeyings of the units digit of the minute of the hour. Miskeying of the units digit of the reported hour (rather than use of round hours, 5.1.3.2) could account for differences of a whole hour that were randomly distributed between forward and backward recall (Table 5.4, line 1). A total of 17% of the cases in the range from 5 to 75 min were times with a unit of hour of difference, indicating a potential keying error in the units digit of the hour timing of activity (Table 5.4, row 1).

5.3.3.3 Use of round times

Reporting in rounded times such as quarter-hours may have contributed to some disparities between reported timings. The great majority of times rounded to minutes of an hour occurred in the 5-75 minute linear range, χ^2 (1) = 3.5, $p < 0.03$ (Table 5.5, row 13). There was a numerically greater incidence of round quarter, half and whole hours in ending times (recall forwards) than in starting times (recall backwards) in this range 5-75 minutes (Tables 5.5 and 5.6, rows 4, 7 and 1), although that observation was not statistically reliable with this number of cases for any tested conditions.

5.3.4 Sources of the higher range of errors

5.3.4.1 Miskeyed time digits

In higher main range of Poisson-linear variation (75-300 minutes), two-thirds of the cases were multiples of 60 minutes (Table 5.4, row 6). This relative incidence of multiples of an hour in this range was reliably higher than that in the lowest range (5-75 minutes), χ^2 (1) = 141, $p < 0.0001$.

5.3.4.2 Other sources of error

The remaining cases were a combination of a multiple of 60 min and a fraction of an hour (Tables 5.5 and 5.6). The small number of cases prevents analysis for sources of these errors. They could include miskeying of the hour, rounded quarter-, half- and whole hours, unreported activities or other types of inaccuracy of report

5.3.5 Error from delay of recall

There was little indication (1 in 6 chance of non-random difference) of disparity in reported timings between the delays of one and two days (Table 5.7).

Table 5.4 Incidences of differences in multiples of a whole hour in the two main ranges.

	Whole-hour multiple	Range from 5 to 75 min	Range from 75 to 300 min
1	1	7	2
2	2	0	3
3	3	0	2
4	4	0	1
5	5	0	1
6	*Proportion (%)*	*17*	*67*

Table 5.5 Incidences of recorded times of events rounded to any minute of the hour in the two main Poisson-linear ranges. Disparities according to sort and sequence of recall.

		Range from 5 to 75 min		Range from 75 to 300 min		Range from 5 to 75 min		Range from 75 to 300 min	
	Minute	For-wards	Back-wards	For-wards	Back-wards	1st recall	2nd recall	1st recall	2nd recall
1	:00	11	9	1	1	12	8	1	1
2	:05	2	0	0	0	0	0	0	0
3	:10	0	0	0	0	0	1	0	0
4	:15	6	4	1	0	6	4	0	2
5	:20	0	1	0	0	0	1	0	0
6	:25	0	0	0	0	0	0	0	0
7	:30	18	13	0	2	15	16	3	0
8	:35	0	0	0	0	0	0	0	0
9	:40	0	2	0	0	0	0	0	0
10	:45	2	3	0	0	0	2	0	0
11	:50	2	2	0	0	2	1	0	0
12	:55	0	0	0	0	1	0	0	0
13	*Proportion (%)*	*79*	*65*	*22*	*33*	*26*	*23*	*57*	*57*

Table 5.6 Incidence of recorded times of events rounded to any minute of the hour in the two main Poisson-linear ranges. Disparities between events occurred one or two days before.

		Range from 5 to 75 min 1 day back		Range from 5 to 75 min 2 days back		Range from 5 to 75 min 1 days back		Range from 5 to 75 min 2 days back	
	Minute	For-wards	Back-wards	For-wards	Back-wards	1st recall	2nd recall	1st recall	2nd recall
1	:00	5	4	6	5	6	3	6	5
2	:05	0	0	0	0	0	0	0	0
3	:10	0	0	0	1	0	0	0	1
4	:15	2	3	1	1	3	2	3	3
5	:20	0	0	0	0	0	0	0	0
6	:25	0	0	0	0	0	0	0	0
7	:30	10	4	8	10	6	8	9	8
8	:35	0	0	0	0	0	0	0	0
9	:40	0	0	0	1	0	0	2	1
10	:45	0	2	1	2	2	0	0	3
11	:50	1	2	1	1	0	1	0	0
12	:55	0	0	0	0	1	0	0	0
13	*Proportion (%)*	*64*	*56*	*71*	*88*	*64*	*50*	*83*	*88*

		Range from 75 to 300 min 1 day back		Range from 75 to 300 min 2 days back		Range from 75 to 300 min 1 days back		Range from 75 to 300 min 2 days back	
	Minute	For-wards	Back-wards	For-wards	Back-wards	1st recall	2nd recall	1st recall	2nd recall
1	:00	1	1	1	0	1	0	0	1
2	:05	0	0	0	0	0	0	0	0
3	:10	0	0	0	0	0	0	0	0
4	:15	0	0	1	0	0	0	0	0
5	:20	0	0	0	0	0	0	0	0
6	:25	0	0	0	0	0	0	0	0
7	:30	0	1	0	2	1	0	2	0
8	:35	0	0	0	0	0	0	0	0
9	:40	0	0	0	0	0	0	0	0
10	:45	0	0	0	0	0	0	0	0
11	:50	0	0	0	0	0	0	0	0
12	:55	0	0	0	0	0	0	0	0
13	*Proportion (%)*	*25*	*50*	*40*	*40*	*50*	*0*	*40*	*20*

Table 5.7 Time differences (in minutes) for one and two days of delay between reported activity and recall.

	Poisson range	*k*	1-day delay			2-day delay			η_p^2	*F*	*p* <
			k	*Mean*	*SD*	*k*	*Mean*	*SD*			
1	5-75	52	28	30.9	21.1	24	23.3	14.8	0.05	2.2	0.14
2	75-300	9	4	125.0	45.3	5	177.0	91.5	0.22	1.1	0.34
3	5-300	59	31	41.6	40.0	28	48.9	70.9	0.10	0.1	0.71

5.4 Discussion

The results of this experiment verified that activities carried out within the preceding two days could be recalled accurately. The descriptions of activities in sequence of occurrence were replicated between forward and backward recall. The timing of the activity was recalled exactly in half the cases. These findings support the assumption in Chapter 3 that the recall of a recent meal is generally veridical.

Most of the cases of disparity between the two reported timings of an activity could be accounted for by procedural factors, rather than being failures of recall. In some cases, the difference in timing by one unit of a digit in the time record indicated that the participant had mistyped the time of the activity in the online questionnaire. Other disparities were in the direction that indicated an unreported intervening activity invalidated the use of the ending time of an activity in recall forwards to estimate the starting time of the next activity, as requested for each activity in backward recall.

There were very few differences in timings unaccounted for, that would have to be attributed to error sources not identified in this study. That is, there was virtually no evidence of error in recall of timings of ordinary activities in the preceding two days. This finding is consistent with results from previous studies that indicate high accuracy of autobiographical memory over the week subsequent to an event (2.3.1).

No interpretable indication of a difference in accuracy of timing was found between one and two days' delay between an event and its recall. This null datum could have resulted from recalling of consecutive activities of any type. The reconstruction of an occasion was extensively prompted by the immediately previous recalling of the preceding or following event(s).

In contrast, the monitoring of frequencies of patterns of eating or exercise in this research is based on the recalling of occasions of specified activities in isolation from the

activities just beforehand or afterwards. Hence it was necessary to complement this experiment with observations extracted from reports of an occasion that was recalled with no more explicit prompting than the wording that specified the particular pattern of eating or exercise (Chapter 6). The tracking studies in this research (Chapters 7 and 8) rely on reports at weekly intervals. Hence successive pairs of reports contain some cases of two recalls of an occasion of eating or exercise a week or more before the second report. It is these data that are used in Chapter 6.

Also, when specified activities have to be picked out in isolation from any day when they last occurred, confusion with similar events is much more likely to accumulate. This interference effect might double from one to two days. Recall is clearly beginning to be affected by omissions and intrusions with increased days of delay since the activity (2.3.1; Armstrong *et al.*, 2000).

Further research is needed on errors in recall of timing of events out of sequence and three days or more beforehand. Nevertheless, within those limitations, this Chapter's evidence supports the use of people's accounts of their diet and physical activity in order to estimate recent frequencies of particular patterns of eating and exercise.

CHAPTER 6
ACCURACY OF TIMING OF AN OCCASION RECALLED TWICE

6.1 Introduction

6.1.1 Aim of the Chapter

The experiment in Chapter 5 analysed the errors in two reports of the same occasion, recalled as one of a series of consecutive activities of any sort. This Chapter investigates the accuracy of the reported timings of occasions of specified eating and exercise patterns recalled without references to prior or subsequent activities. Also, instead of the two reports being separated by a fraction of an hour as in Chapter 5, they were made a week apart. The data came from the weekly monitoring presented in other aspects in Chapter 9.

6.1.2 Approach

If one of the two most recent occasions of a particular pattern of eating or exercise is reported to have been at a time before the previous weekly report, that occasion should be one of that report's two most recent episodes. Hence, the difference in reported timings between the two recalls of the same occasion measures inaccuracy in remembering or recording. This Chapter tests if there are distinct sources of such error and seeks to characterise the factor that produces each type of error.

6.1.3 Expected findings

6.1.3.1 Ranges of variation

Distinctive sources of inaccuracy are demonstrated by regions of linearity in the logarithmic probability plot ('survival' function) of differences between reported timings of an occasion (5.1.3.1). Several factors in the processes of recalling the event and recording its timing could have produced error in one or both of the timings.

6.1.3.2 Hypothesised sources of error

Mis-keyed timings. A participant could enter a digit of the reported time or date incorrectly. The resulting difference in time would depend on the place of the digit in the format required for recording calendar date and time of day.

Differences in recorded timing could arise from hitting a key adjacent to the key for one of the digits ("0" to "9") in the minute or the hour for one of the two timings. This error in the movement of a finger becomes less likely from 1 to 2 minutes or hours and from 10 to 20 minutes or hours, and even less likely the further apart are the intended and hit keys.

Miskeying of the day of the month ("01" to "31") could produce an error in recorded time of between 1 and 9 days if the key for units of the day was mis-hit, or of 10, 20 or even 30 days (or more) if the miskeying was in the tens of the day.

Miskeying of the month ("01" to "12") in one of the timings would increase the difference in timings to a multiple of around 30 days. Miskeyings of both month and day in one or both recorded timings could produce intermediate differences in timing. For example, if the recalled date was 07/02/2010 but the participant mistyped the month units digit as 07/01/2010, and the other reported timing was 01/02/2010, the time difference would be 25 days. Such cases might be distinguishable in the analysis of probability distributions.

If the last digit(s) of the year were keyed mistakenly, the difference in timings would increase in multiples of about 365 days. Again, the distribution of time differences attributable to miskeying of the year could be widened or narrowed by miskeyed months or days in addition.

A special case of miskeying, involving a sort of memory error that is independent of recall of timing, is a carry-over of the past month and/or year to the early part of a new month or year. Such an error can be unequivocally identified as hitting the wrong key(s).

Round timings. The rounding of time on the clock to the nearest 5, 10 or 15 minutes, or whole hour, during or after recall of the timing of an occasion might account for some differences between the two recorded timings (5.1.3.2).

Delay between reported occasion and report. The accuracy of recall of past autobiographical events decreases over time (2.3.1). Hence, for an occasion reported to have occurred before the previous weekly report, the longer the delay from that occasion to report, the greater should be the incidence of difference in recalled timings between the two consecutive reports.

6.2 Method

6.2.1 Design

The study in this Chapter had an experimental design with comparisons within subjects. The full method of the study that obtained the timings of eating and exercise occasions analysed in the present experiment is described in Chapter 9 (9.2).

6.2.2 Procedure

The timings of the two most recent occasions of each eating or exercise pattern were reported each week in the format Hours:Minutes am/pm Day:Month:Year (similarly to one of the options in Excel). Participants were advised to use a calendar of the current year to help

them see the number of the day. To prompt participants' memory of the time and date of the target occasion, they were advised to remember first the place where it occurred and the people who were present.

6.2.3 Difference between reported timings of the same occasion

Occasions dated before the previous report were identified in each weekly report obtained for Chapter 9. The earlier occasion could be either of the two occasions recorded in the preceding report. The second report's timing of the occasion was subtracted from the timings of each of the occasions in the earlier report, to give two (positive) values of difference in times, expressed in days.

6.2.4 Analysis of data

6.2.4.1 Ranges of variation

All the 4032 time differences obtained were combined into a single 'survival' distribution in order to identify Poisson-linear ranges (as described in 5.2.4.2).

6.2.4.2 Sources of error

Mis-keyed timings. The contribution of a hypothesised type of mis-hit on the numerical keys to observed differences between timings was initially identified by the overlap of its range of time errors with the range of time-differences in a Poisson line. This identification would be proved if cases unambiguously arising from that miskeying were reliably more frequent in the Poisson range than in the rest of the distribution. For example, multiples of 10 minutes of difference between the two recorded timings of an occasion are unambiguously instances of mis-hitting the tens digit of minutes if one of the times is within 5 minutes of the exact 10 minutes in the other timing reported.

Rounded times. Differences in timing arising from rounding to the nearest 5, 10 or 15 minutes (including 30 and 45 minutes and a whole hour) were initially identified by assignment with any observed Poisson range that overlapped with the expected range of errors in recorded timing. For example, rounding to 5 minutes would range up to 2 minutes, while rounding to the quarter-hour could range up to 7 minutes. Again, this identification could be established by reliably greater observed than expected incidence within a Poisson range of unambiguous roundings of a particular type, e.g. one timing being on a multiple of 5 minutes and the other being 1 or 2 minutes on either side of that minutes point. Note that, in this analysis, the difference is not a multiple but one of the recorded timings.

The relative incidences of unambiguous cases of rounding inside and outside a Poisson line were evaluated for reliability by one-tailed χ^2.

6.2.4.3 Effect of delay on accuracy of recall

The cases of differences in timing for each type of error (6.2.4; Figures 6.1 to 6.5) were divided between shorter and longer delays between reported timing and time of report, at the median delay for that error. If delay caused inaccuracy, the timing difference should be less with the shorter delay, in a test of central tendencies by ANOVA.

6.3 Results

6.3.1 Incidence of disparity in reported timings

The two reported timings of an occasion more than a week previous to the second report were the same in 16% of the cases (648/4032). However, this underestimates about half of the available matches as only one of the two occasions recorded in the later week that were considered could be the occasion recorded in the earlier week. In the remaining 84% of the cases, differences in the times ranged from 0.04 to 38017 days, but 97% of the differences were less than 36 days.

6.3.2 Ranges of variation in time differences

The incidences of time differences up to 35 days showed several modes (Figure 6.1). Each of these peaks of incidence appears to be approximately normal in distribution.

A ‘survival’ plot of the whole distribution showed a corresponding succession of straight lines indicating ranges of difference in timing that arise from distinct causes (Table 6.1, left-hand columns). The range of the smallest time differences [included in the cases analysed] with the best fit to a straight line was from 0.04 to 0.08 days (60-120 min; Figure 6.2). The next linear region ranged from 0.17 to 0.90 days (240-1290 min; Figure 6.2). The next largest time differences giving this evidence of a single cause were 1-10 days and then 10-16 days (Figure 6.3). The series of straight lines continued without a break (i.e., a rounded ‘corner’) to differences of around a month, with a range of about 18 to 30 days and then 30 to 36 days (Figure 6.3). There was then a gap between linear regions of the log probability distribution until time differences of about a year. These lines of best fit had ranges of 295-308 days and 357-361 days (Figure 6.4). Finally there were two linear regions of about 10 years (3277-3644 days) and 20 years and over (6932 to 3941 days; Figure 6.5).

Figure 6.1 Histogram (frequency polygon) of the observed differences between timings of occasions of eating or exercise recorded in consecutive weekly reports. In this Figure, the counts limited to differences of up to one month only.

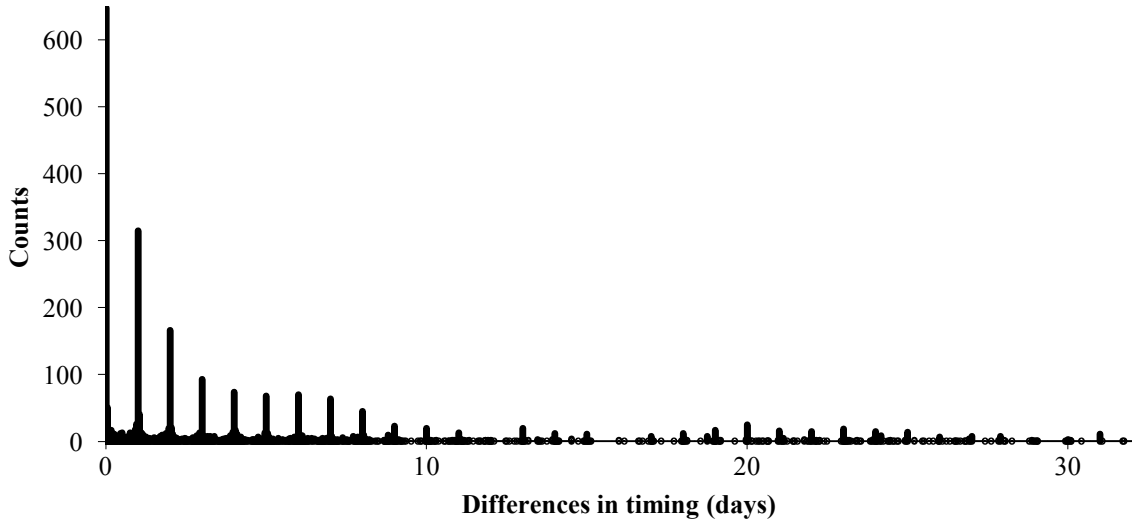


Table 6.1 Ranges of the differences between two reported timings (days) of a prior occasion of eating or exercise, observed in linear regions of the logarithmic probability function. k = cases observed in the range. k_u = cases unambiguously resulting from the hypothesised source of a difference between recorded timings.

	Observed difference between timings (6.3.2)					Hypothesised difference (6.1.3)		
	Name of 'stick'	k	*Mdn*	Range (days)		Range	k_u	Source of error
				Smallest	Largest			
1	One minute	89	0.04	0.01	0.05	1-2 min	0	Miskey minutes unit
2	Few minutes	89	0.04	0.01	0.05	1-3 min	0	Round to 5 min
3	Tens of min	89	0.04	0.01	0.05	10-20 min	82	Miskey minutes tens
4	Quarter-hours	89	0.04	0.01	0.05	1-7 min	0	Round to 15 min
5	An hour or two	85	0.04	0.04	0.08	1-2 hr	68	Miskey units of hour
6	Several hours	233	0.5	0.17	0.90	10-20 hr	165	Miskey tens of hour
7	One day apart	355	1.0	0.98	1.02	1-2 days	315	Miskey day in month
8	A week apart	1887	4.0	1.02	9.98	7 days	603	Mistake which week
9	Two weeks	188	12	10.0	16.0	10-20 d	79	Miskey tens of day
10	Under a month	309	23	18.5	29.9	up to 31 d	139	Miskey the month
11	A month or so	72	31	27.9	36.0	30-31 d	25	Carry over the month
12	Ten months	21	300	295	308	304 d	21	Miskey month tens
13	Up to a year	5	358	357	361	365 d	5	Miskey year units
14	Up to a decade	6	3E3	3277	3644	3653 d	6	Miskey year tens
15	About 2 decades	4	7E3	6932	6941	7306 d	4	Miskey the century

Figure 6.2 Linear regions identified in the distribution of differences between timings of tested occasions from consecutive weekly reports (timing differences ranging from 0.1 to 1.2 days).

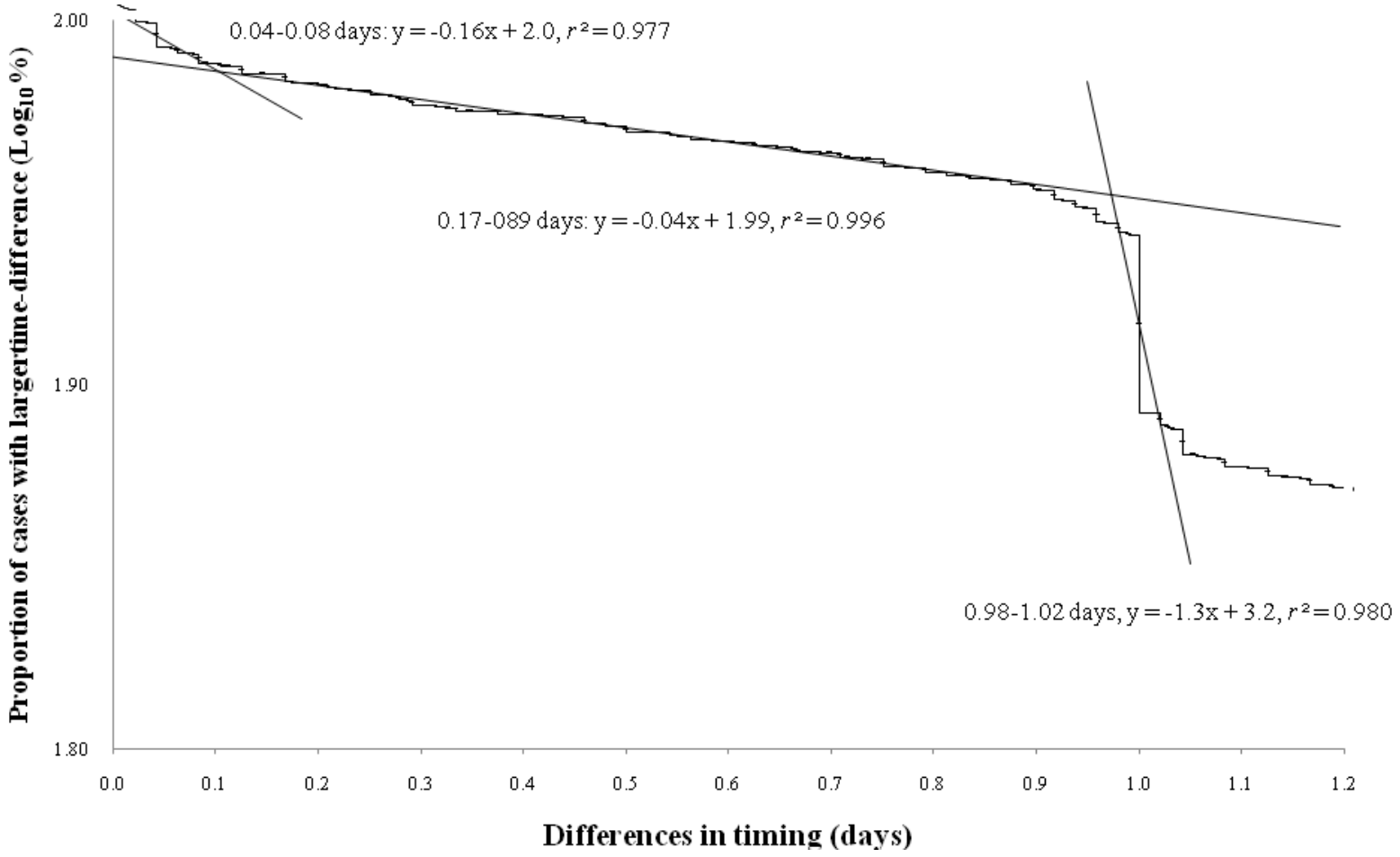


Figure 6.3 Linear regions identified in the distribution of differences between timings of tested occasions from consecutive weekly reports (difference in timings from 0.01 to 60 days).

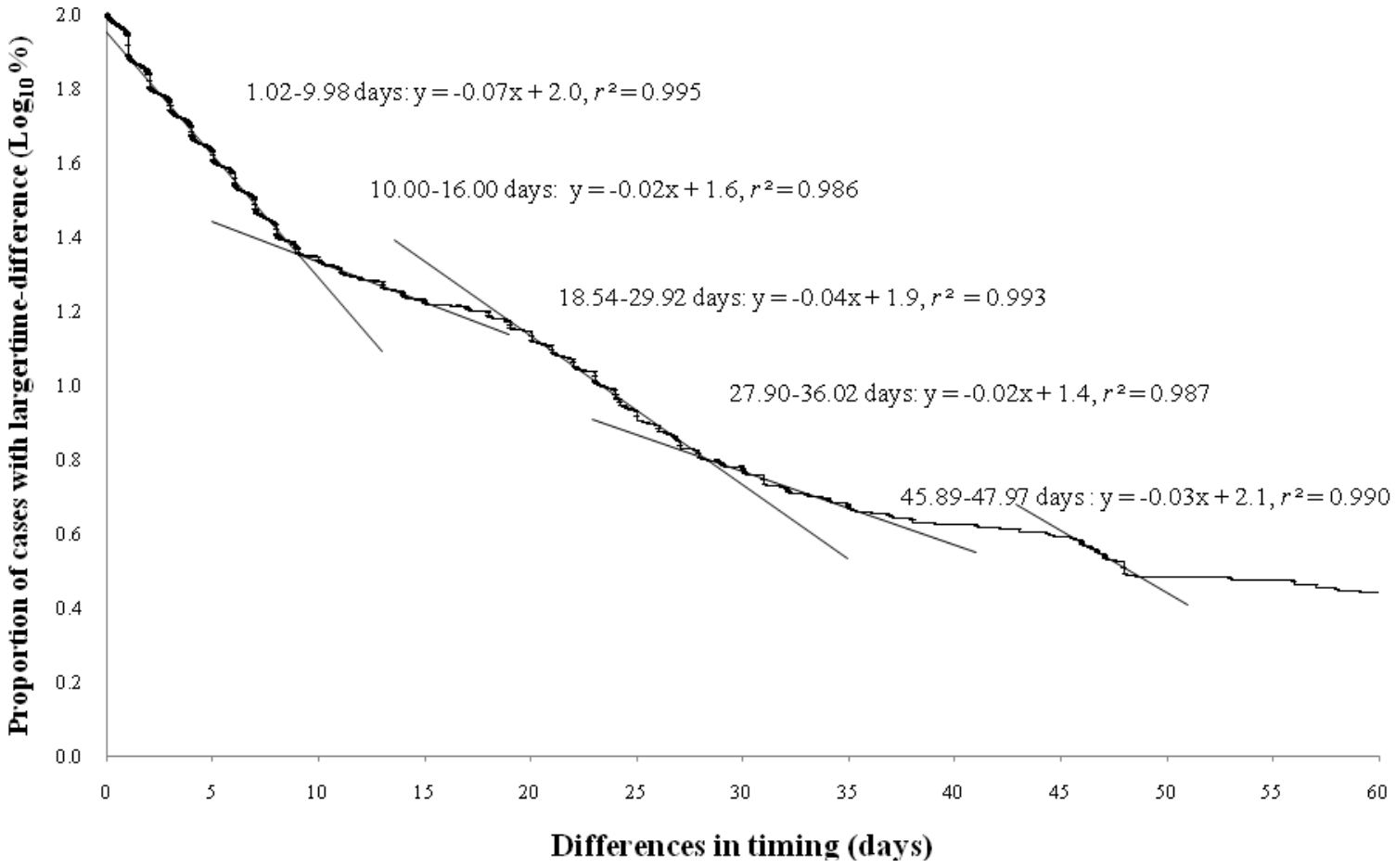


Figure 6.4 Linear regions identified in the distribution of differences between timings of tested occasions from consecutive weekly reports (differences from 100 to 1000 days).

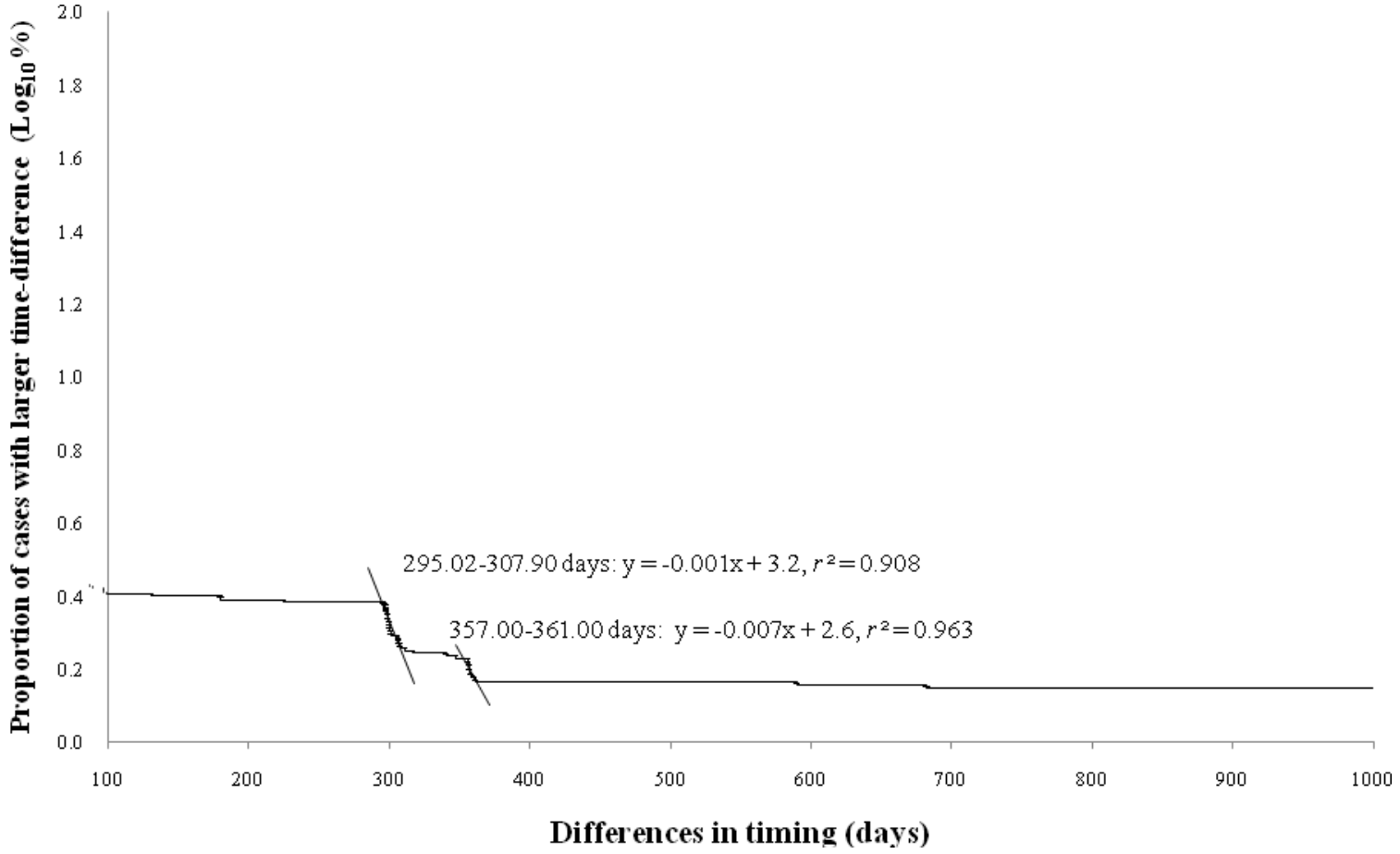
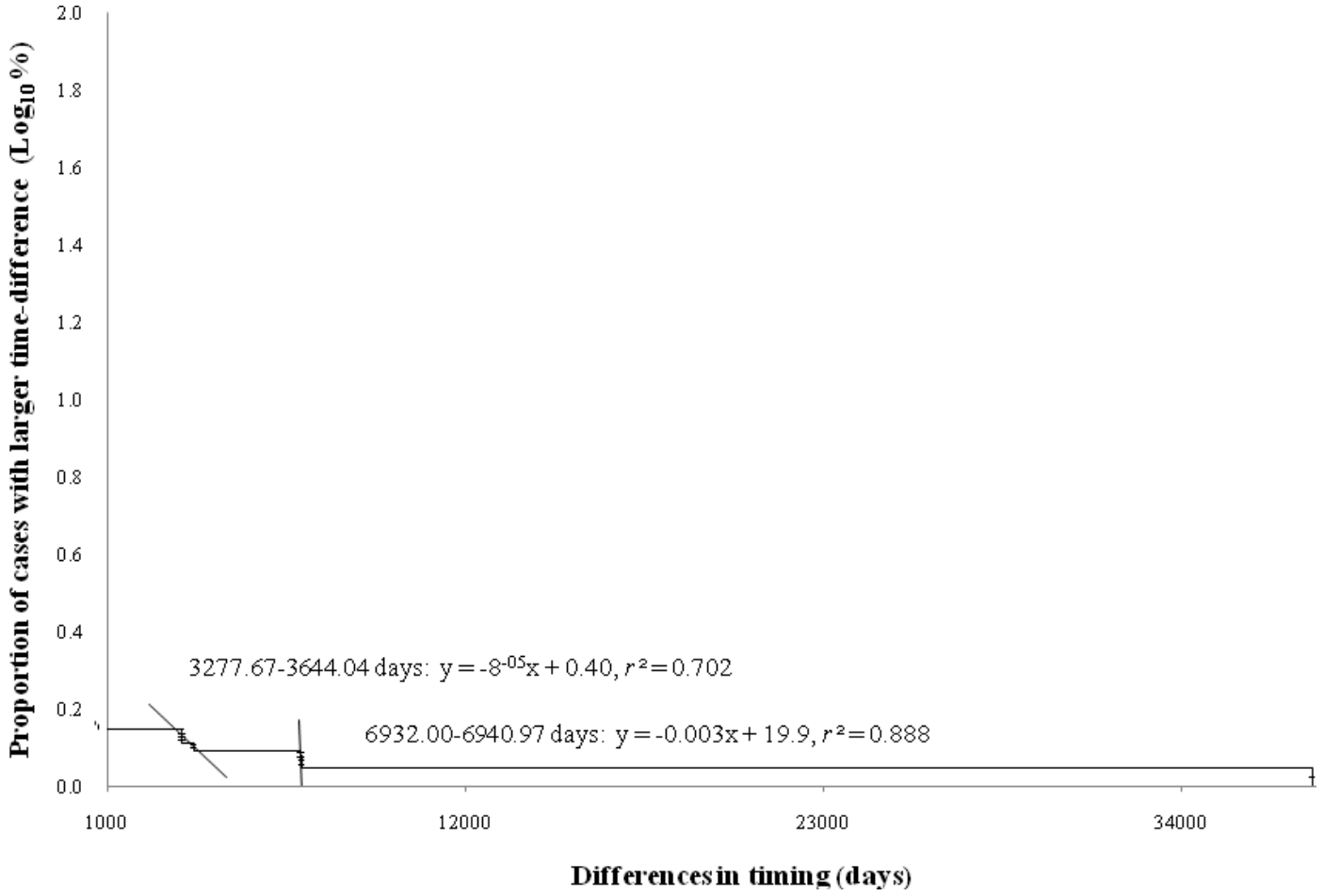


Figure 6.5 Linear regions identified in the distribution of differences between timings of tested occasions from consecutive weekly reports (time differences ranging from 1000 to 3400 days).



6.3.3 Hypothesised sources of error

6.3.3.1 Miskeying of timings

All the above observed Poisson-linear ranges of differences in timing overlapped with an hypothesised distribution of recorded differences arising from one type of miskeying (Table 6.1 rows 1-11). That is, each piece of evidence for a single source of error matched a possible type of mis-hitting of the keyboard.

6.3.3.2 Rounded times

Participants approximated the recalled times of events to the nearest fraction of the clock, thus, no error in timings from disparities between rounded and non-rounded times was inferred (Table 6.1, row 1, 2 and 4). Also, no difference between earlier and later occasions was seen in the almost universal use of the 5-minute or quarter-hour times on the clock in the range of smallest time-differences, 43% *vs.* 43%, χ^2 (1) = 0.00, $p < 1.00$.

6.3.3.3 Effect of delay between occasion and report

An effect of delay between occasion and record was found in each of the Poisson-linear ranges of time differences from one day to one month (Table 6.2, rows 3-7). When the delay between occasion and report was shorter than the median delay for a range, the differences between timings were smaller.

Table 6.2 on next page

Correlation of duration of delay with timing difference across cases showed that a linear effect underlay that difference in means across a median split (Table 6.2, rows 3-6, further right-hand columns). For example, the largest effect of delay was observed in the Poisson range of about a week, which also had the strongest positive correlation (Table 6.2, row 4).

6.4 Discussion

The data on this Chapter are the more relevant to the habit tracking approach of this Thesis than those of Chapter 5 because they come from records of patterns of eating and exercise patterns recalled in isolation from other events.

Hence as much information as possible should be extracted from the findings in this chapter about the accuracies of the estimates of frequency from two recalled timings during weekly monitoring. The proposed Poisson's analysis (5.2.4.2) showed that although errors in recording blur the effects of all the other errors, each source of error was independently separated from other sources even when they interacted on observations.

Table 6.2 Timing differences (in days) above and below median delay from reported occasion to the recording of its time.

	Variation	*k*	Delay in days	Differences below *Mdn* delay		Differences above *Mdn* delay		η_p^2	*F*	*p* <	*rho*	*p* <
			Mdn	*Mean*	*SD*	*Mean*	*SD*					
1	An hour or so	85	2.03	0.06	0.02	0.05	0.02	0.03	2.2	0.14	0.50	0.45
2	Many hours	233	5.73	0.52	0.25	0.52	0.22	0.00	0.0	0.98	0.50	0.45
3	One day	355	2.97	0.99	0.01	1.00	0.01	0.002	0.7	0.40	0.10	0.05
4	Up to a week	1894	8.15	3.58	2.09	4.82	2.30	0.07	148	0.00	0.38	0.00
5	Two weeks	187	13.6	12.0	1.47	12.6	1.81	0.04	7.8	0.01	0.20	0.01
6	One month	309	32.2	22.6	2.81	23.4	2.78	0.02	5.7	0.02	0.17	0.00
7		72	18.2	31.7	2.56	30.8	2.24	0.03	2.3	0.13	-0.22	0.06
8	One year	21	366	299	3.18	302	4.02	0.11	2.4	0.13	0.39	0.08
9		5	368	359	2.10	358	0.71	0.31	1.4	0.33	-0.08	0.89
10	One decade	6	3289	3280	1.82	3644	0.15	1.00	7E4	0.00	0.72	0.11
11	Two decades	4	6945	6932	0.71	6940	0.69	0.99	130	0.01	0.89	0.10

6.4.1 Worsening of error with time between event and recall

Times that were assigned a week apart to a past occasion of eating or exercise often differed. The size of this error in one or both of the timings was sensitive to the length of time between the recalled occasion and the recording of its timing, at least for some types of timing error. Indeed the relationship of error to delay had a linear component, since the correlation was high when there was a highly reliable difference between the means on either side of the

median. However, the statistical size of effect was never large (when there were more than 20 cases), e.g. $\eta_p^2 = 0.11$ or 0.07 (the two highest).

This increase of error with delay presumably arises from the long-known decline in memory with time, whether by decay of the memory trace, confusions among memories and/or other mechanisms (2.3.1). The present data may point to a confusional process. The strongest evidence came from the commonest error, which was a difference in timings by a few days. The error increased by a mean of about one day on going from less to more than a week between the occasion and the assignment of a time (i.e. from the earlier to the later weekly report). Going from one to two weeks between event and recall would have about doubled the number of potential confusions between events on different days of the week.

6.4.2 Design of the full experiment

One implication of these findings, as also from the findings of Chapter 5, is that a method of recording recalled times needs to be found that is not liable to the hitting of incorrect number keys. Such a procedure is proposed in the plan in Chapter 11 for a full experiment.

In spite of that difficulty with the reporting technique used in this Thesis, the observations in this Chapter from successive weekly reports provide evidence that recency improves accuracy of recall over periods of a week and longer.

PART D

ERRORS IN RECORDING OF WEIGHT

CHAPTER 7
DIFFERENCES BETWEEN RECORDED WEIGHT AND ACTUAL WEIGHT

7.1 Introduction

7.1.1 Aim of the Chapter

The evidence on habits that reduce weight in the present research relies on participants' records of their weight each week. This Chapter assesses potential causes of inaccuracy in recorded weight by using the data on weights in the records returned during the monitoring reported in Chapters 8 and 9.

7.1.2 Approach

The extent of variation in recorded weight was measured from the differences between weeks in the weight recorded by each participant.

If a random source of error affects the weights, there should be a normally distributed peak of incidences in the weekly differences and a linear region of the log probability 'survival' plot (Poisson analysis: Chapter 5, section 5.1.3.1). Any such regions are then matched with the ranges of differences predicted for hypothesised sources of error.

7.1.3 Expected findings

7.1.3.1 Weekly differences from change in weight

Various sources of inaccuracy in records of weight on the scales are hypothesised below. However some differences between weeks in recorded weight should come from changes in actual weight. The sizes of actual changes are unlikely to vary randomly and so no Poisson-linear range would be hypothesised.

Furthermore, changes in weight are liable to recur in successive weeks. This criterion might pick out some real changes, especially if random errors are not too frequent.

7.1.3.2 Errors from weighing

Accuracy of weighing scales. The difference between weights of the same person measured successively in the same scales is less than 0.5% (Chapter 1, section 1.4). If the mean weight of participants is 62±11 kg, the possible week to week variation from the scales can range between 250 and 350 g. Therefore, specific variation in recorded weights was sought in such range.

Variation from weighing practices. Eating or drinking or not evacuating bowel and bladder contents before weighing can increase until 500 g of weight. In a similar manner,

wearing clothing and/or shoes at the moment of weighing can add up to 2 kg. Thus, ranges of variation in recorded weights up to 500 or 2 kg attributable to weighing practices were sought.

7.1.3.1 Errors of recording

Social desirability. If a substantial number of the participants desired a slim figure, there might be a common tendency to report a weight lower than that seen on the scales (1.4). If this tendency declined or was exacerbated over the weeks or reporting, that could cause differences in recorded weight between weeks. However, a constant bias or an effect of the bias on expected weight loss would not be detectable as week-to-week variation

Unfamiliarity with weight units. Students may talk about their weight in terms of stones and pounds. However, many scales display weight in kilograms or pounds. Hence errors may arise from converting the reading on the scales into the recorded weight, even though the options of kg or lb were provided. These errors are unlikely to be more than 1-2 kg. Nevertheless that range could be superposed on any of the ranges from other types of error.

Rounding. Those who record in kg may round 0.5 to a whole number. Those who use stones and pounds may round to the nearest stone or 7 lb (half a stone). Conversion to kg from reading in stones and pounds or in pounds (lb) could also produce rounding to the nearest whole kg. Rounding errors could therefore have a similar range to conversion errors.

Miskeying of record. Some participants could have entered the weight wrongly into the record via the internet. One source of error could be mis-hitting the number key in the array from 0 to 9 on the keyboard in any of the digits in the kilograms, stones or pounds used for entry. For instance, a participant could press 9 instead of 8 stones causing a difference of one stone (about 6 kg) from the preceding and following week if weight is constant. Such errors are most unlikely to occur in successive weeks.

A mis-hit is most likely on an adjacent key. Hence errors of 1 in the units or tens are most likely, accounting for peaks at the corresponding point in kg and a Poisson line spanning those peaks. A difference of 9 could arise from miskeying 0 as 9. The usual keyboard array from 1 through 9 to 0 could not produce a difference of one from an intended keying of 0, or a mis-hit of 1 as 0.

7.2 Method

7.2.1 Design

This Chapter uses comparisons within subjects of data collected for Chapters 8 and 9 in the design described there.

7.2.2 Procedure

Participants were asked to take a reading from the same scales at the same time on the day of their weekly report, preferably after getting up and before a usual meal, having relieved themselves and wearing at most light clothing with no shoes.

7.2.3 Measurement

Each individual's week-to-week variation in recorded weight was measured as the difference between the two weights in consecutive weekly reports, subtracting the later week from the earlier week. All the eligible weights recorded by participants over the monitoring in Chapters 8 and 9 were included. All the weight differences were combined into a single set for analysis, providing 860 cases.

7.2.4 Analysis

The distribution of absolute (unsigned) differences in weight was analysed for regions of linearity in the survival function as described in Chapter 5, section 5.2.4.2, omitting the step of constructing a histogram. The range of each line was determined by the maximum r^2 observed with truncations and extensions of each extreme of a linear region visible in the survival plot (Table 7.1). These ranges of the Poisson-linear regions were then inspected for overlap with the ranges hypothesised for sources of error in weighing and recording weight under the conditions used in this research.

7.3 Results

7.3.1 Differences in recorded weight between successive weeks

In 32% (273/860) of the cases, there was no difference between the weights recorded in two consecutive weeks. Where there was a difference, the incidences of increase and decrease in recorded weight did not differ appreciably, with 290 (34%) of all cases having difference values lower than zero and 297 (35%) being higher than zero. On this evidence, weight did not fall or rise in general during the monitoring in Chapters 8 and 9.

7.3.2 Ranges of weight difference affected by specific random errors

There were at least six linear regions in the survival plot of absolute differences in recorded weight between weeks (Figure 7.1; r^2 values between 0.98 and 0.998). There were probably a seventh 'stick' at around 2.4-2.8 kg, after a rounded region between 2.1 and 2.4 kg – or even another short 'stick' between 2.1 and 2.3 kg; these regions remain to be evaluated for distinct ranges by linear regression.

Table 7.1 Identification of the ranges of linear regions of the survival plot. T = tested range of time differences.

		Difference in weight								
			Range (kg)							
		k	low	high	r^2		Inferences		Intercept	Slope
1		35	**0.1**	**0.2**	1.000	+	supported	*best fit*	2.00	-0.12
2		43	**0.1**	**0.3**	0.993	+	supported			
3	T	127	0.1	0.4	0.966	–	refuted			
4		196	0.1	0.5	0.969	–	refuted			
5		213	0.1	0.6	0.974	+	supported			
6		219	0.1	0.7	0.944	–	refuted			
7		107	0.2	0.4	0.964	–	refuted			
8		228	0.2	0.6	0.886	–	refuted			
9		196	0.3	0.5	0.969	–	refuted			
10	T	213	0.3	0.6	0.972	–	refuted			
11		207	**0.4**	**0.6**	0.989	+	supported			
12		189	**0.4**	**0.5**	1.000	+	supported	*best fit*	2.3	-0.92
13		212	0.4	0.7	0.945	–	refuted			
14		312	0.4	0.9	0.959	–	refuted			
15		136	0.5	0.8	0.878	–	refuted			
16	T	228	**0.5**	**0.9**	0.985	+	supported	*best fit*	2.0	-0.41
17		285	0.5	1.0	0.925	–	refuted			
18		122	0.6	0.9	0.920	–	refuted			
19		166	0.7	1.1	0.898	–	refuted			
20		99	0.8	0.9	1.000	+	supported			
21		157	0.8	1.0	0.977	+	supported			
22	T	160	0.8	1.1	0.971	–	refuted			
23		169	0.8	1.2	0.897	–	refuted			
24		148	**0.9**	**1.0**	1.000	+	supported	*best fit*	2.9	-1.32
25		152	**0.9**	**1.1**	0.984	+	supported			
26		160	0.9	1.2	0.878	–	refuted			
27		63	1.1	1.5	0.952	–	refuted			
28		54	1.2	1.4	0.973	–	refuted			
29	T	61	**1.2**	**1.5**	0.982	+	supported	*best fit*	2.2	-0.58
30		66	1.2	1.6	0.969	–	refuted			
31		55	1.6	2.1	0.953	–	refuted			
32		33	1.7	1.9	0.984	–	refuted			
33		48	1.7	2.0	0.994	+	supported			
34	T	49	1.7	2.1	0.993	–	refuted			
35		53	1.7	2.2	0.966	–	refuted			
36		47	**1.8**	**2.1**	**0.998**	+	supported	*best fit*	2.5	-0.76
37		50	1.8	2.2	0.961	–	refuted			

The reliabilities of differences between the estimated exponents of these Poisson functions (the slope of each regression line) remain to be determined but there appear to be three distinct groups, i.e. sets of potentially parallel lines. The two similarly most powerful sources of error (steepest slopes, around 1) affected errors around 0.5 kg and 1 kg (Figure 7.1). The intermediate set fell in the overall range of differences of 0.4 kg to 2.1 (or perhaps 2.4) kg, with slopes of about 0.5). The lowest slopes, i.e. the evidence for the least powerful generators of differences, covered the smallest and (perhaps) the largest differences (slope about 0.2).

None of the 'sticks' had a reliably non-random split between increases and decreases in recorded weight from one week to the next (Table 7.2). Hence there was no evidence that a source of error in recorded weight was associated with a bias such as wishing to seem lower in weight.

Among the cases of a difference in recorded weight between weeks, more than twice the records were in stones and pounds than in pounds alone or in kilograms (Table 7.2). However, two ranges went in the opposite direction, with more use of kg or lb than of stones and pounds. These were the two 'sticks' with the lowest slopes, the range of smallest differences (0.1-0.3 kg) and the largest differences (> 2.1 kg) – potentially dominated by the other sticks with the lowest slope. Hence both these weak sources of error may be associated with records of actual readings on the scales.

7.3.3 Hypothesised sources of error

Exponents around 1. Since the two ranges of 0.9-1.1 kg or 0.4-0.6 kg (Figure 7.1) are among those most predominantly using of stones and pounds in their records (Table 7.2), the source of error in both ranges could be a difference in rounding to a weight in kg or lb (~0.5 kg) during conversion from the kilograms or pounds marked on the weighing scales.

Exponents around 0.5. The three (or maybe four) ranges with intermediate slope are in the middle region between 0.5 and 1 kg, 1 kg and 2 kg (two ranges) and maybe 2 kg and 3 kg (Figure 7.1). Possibly this diversity of ranges is dominated by various sorts of deviation from the standard weighing procedure, such as a difference in clothing, omitting to eliminate or weighing after a meal.

The range that goes beyond the middle, up to 2.1 kg, is also the steepest stick (visibly and numerically at least): both may be indications of the operation of an additional source of error, such as one accounting for an exponent of 0.2.

Figure 7.1 Poisson-linear regions indicating disparate types of random error in differences in recorded weight from one week to the next.

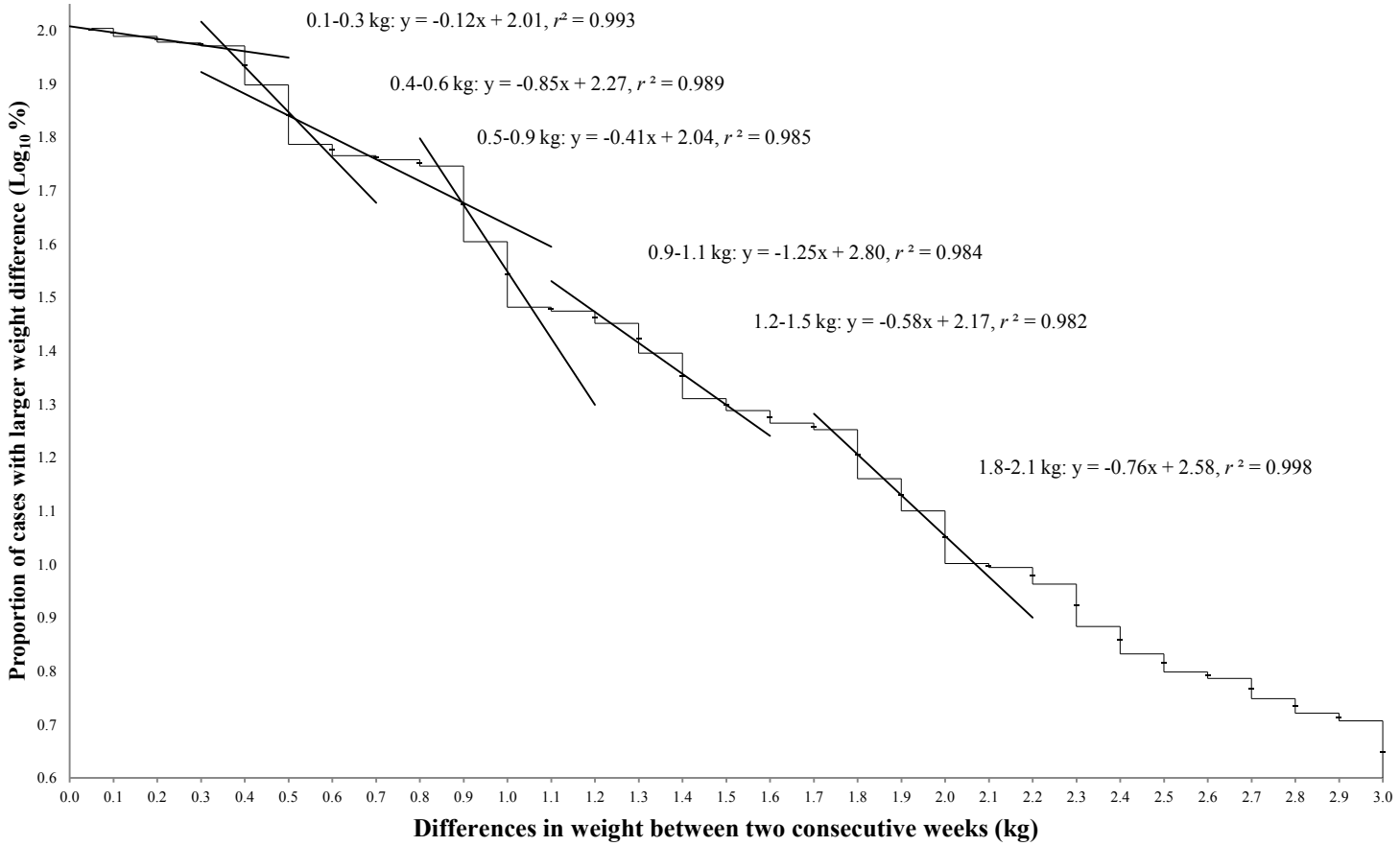


Table 7.2 Incidences of potential sources of error in recording weight. %: percent of all cases. (%): percent of cases in the range of differences on that line.

	Week-to-week difference (kg)	*k*	%	Increase *k* (%)	Decrease *k* (%)	Stones and pounds *k* (%)	Kilograms or pounds *k* (%)
1	0.1-0.3	43	7	24 (56)	19 (44)	15 (35)	28 (65)
2	0.4-0.6	207	35	97 (47)	110 (53)	178 (86)	29 (14)
3	0.5-0.9	228	39	115 (51)	113 (49)	194 (85)	34 (15)
4	0.9-1.1	152	26	87 (57)	65 (43)	105 (70)	47 (30)
5	1.2-1.5	61	10	32 (52)	29 (48)	47 (77)	14 (23)
6	1.8-2.1	47	8	23 (49)	24 (51)	28 (60)	19 (40)
7	> 2	53	9	25 (47)	28 (53)	23 (45)	29 (55)
8	0.05-28 kg (all cases)	587	100	297 (52)	290 (48)	415 (71)	172 (29)

Exponents around 0.2. Differences of 0.1-0.3 kg might well have quite a different explanation from differences of 2.4-2.8 kg (Figure 7.1). It is difficult to see how either range could come from miskeying. Possibly one or both ranges come from an occasional change in rounding strategy.

Some of these identifications might be supported or undermined by more detailed analysis, such as examination of the two weights that produced the difference. If only one were on a 'round' units or tens digit, it might be possible to narrow the options (compare Chapter 6, section 6.3.3).

7.4 Discussion

7.4.1 'Underreporting' of weight

If the records of weights seen on the scales were biased downwards by social desirability or self-image, as reported weights are widely suspected to be (2.4), there could have been a trend downwards over the whole set of data or in an error such as rounding. There was no trend in that direction, even just numerically.

It is conceivable that the bias operated from the first report and remained constant throughout the tracking. Yet that possibility is hardly more likely than such a bias coming into full operation as monitoring got under way or attenuating as the weekly routine of weighing settled in.

Since this analysis does not detect the accumulation of differences, there is no way of assessing biased expectations of weight loss. That issue is addressed in other ways later in the Thesis, by the analysis of variation of weight from multiple measurements in succession over the weeks of monitoring (8.3.2) as well as the causal analysis of weight change alongside behaviour change (Chapters 8 and 9).

7.4.2 Use of stones and pounds

Thinking of readings in kilograms or pounds in terms of stones and pounds for the record could be produced several errors (a steep exponent in the survival plot), i.e. be a powerful cause of error in recorded weight. It may therefore be better to insist on use of the units read from the weighing scales, e.g. by not providing the option of a st. lb. record or requiring registration of units used at the start of monitoring.

7.4.3 Correction of anomalies

Variations in the participant's procedures may be impossible to eliminate. Nevertheless it might be possible to correct particular data for a specific variation identified by additional information, such as reporting of a deviation from the usual procedure or its detection by remote sensing (by agreement).

PART E

EFFECTS ON WEIGHT OF CHANGED FREQUENCY OF EATING OR EXERCISE PATTERNS

CHAPTER 8
EFFECTS OF UNASKED AND REQUESTED CHANGES IN FREQUENCY OF A PATTERN OF EATING OR EXERCISE

8.1 Introduction

8.1.1 Aims of the Chapter

The primary purpose of this Chapter is to present examples of causal analysis of associations between changes in behaviour and hypothesised consequences, using cross-lagged correlations with testing for third factors (2.6). The data come from the first use of the internet to track the individual's weekly records of weight read from bathroom scales and of recalled timings of the two most recent occasions of each of a set of customary patterns of eating or exercise. During the monitoring, some of the participants changed the frequency of one or more of the eating or exercise patterns. These unasked changes presented an initial opportunity for using causal analysis to measure the effect on weight of a change in how often a particular pattern of eating or exercise is carried out (2.6).

This first attempt at close tracking of eating, exercise and weight needed to check participants' compliance with the requirements of weekly online reporting of weight and timings. It was also necessary to test the procedures for identifying individually feasible changes in eating or exercise within a group experimental design using multiple baselines in each of the single cases (2.7).

8.1.2 Approach

Participants reported weekly the weight reading on their scales and their recall of the timings of the two most recent times of specified eating and exercise occasions, with a view to changing the frequency of one of those patterns on request.

The effect on weight of a change in frequency of a pattern of eating or exercise was measured as the ultimate change in weight while a change in frequency was being maintained. The analysis for direction of causation was applied both to changes in frequency that were requested and to those that occurred before any request had been made.

8.2.3 Expected findings

The general hypothesis was that a sustained change in the frequency of a pattern of eating or exercise causes a change in weight towards an asymptote within a few weeks (2.1). The start on evidence for such causation is the change in frequency of a pattern that correlates in size across participants with the change in weight. The direction of causation from

behaviour to weight is identified by time-lagged correlation in which the change in frequency begins before the change in weight.

All monitored eating and exercise patterns' changes in frequency were tested for correlations with concurrent change in each other pattern of behaviour that was monitored. If patterns are not related conceptually (Chapters 3 and 4), correlated changes in frequency indicate that a third factor is causing the changes in behaviour as well as any change in weight. This factor could be motivation to eat or exercise healthily. In particular, one pattern might replace another, indicated by negative correlation between their changes in frequency.

For a pattern that has been confirmed to cause a change in weight, the slope of a regression across participants from that change in frequency to an asymptotic change in weight measures the pattern's effect on weight in that sample.

8.2 Method

8.2.1 Participants

A total of 77 psychology students from the University of Birmingham took part in this study. The participants were mostly British females (94%). The mean age was 20 years (*SD* = 2.7 y). Their stated ethnic backgrounds were white British (80%), south Asian (8%), white European (3%), black African (2%) and black Caribbean (2%), with 5% others or undeclared backgrounds. They agreed to take part in a study of self-monitored weight, eating and exercise patterns, including changes of behaviour in a healthy direction on request.

8.2.2 Design

The study reported in this Chapter was mainly observational in a cohort design, with a concluding quasi-experimental phase. Each volunteer in the cohort took part in a weekly online session for several weeks. The design of analysis was first within-subjects comparisons among habits and weights over weeks, followed by aggregation across subjects having relevant observations.

8.2.3 Procedure

8.2.3.1 Recruitment session

The study was posted on the website for research participation in the School of Psychology (RPS, Sona Systems Ltd), with the title *Memories of eating and movement*.

A total of 140 students completed an initial sample of the online questionnaire. They were then invited to fill in the same questionnaire online each week for eight weeks. The students were informed that they would need access to scales for self-weighing before doing

the report each week. They were also informed that their responses would be kept anonymous and that they would be identified only through their ID number in the RPS website. Once they had completed eight weekly reports, participants received credits towards a requirement of their degree course to take part in research.

The majority of the students ($N = 89$) agreed to take part in the 8-week study, 21 responded that they would not like to take part and 30 maybe they would like to take part. A small minority (13%; $N = 12$) of the initial volunteers ended their participation before the eighth week.

8.2.3.2 Monitoring

To obtain weekly records of weight under constant conditions (2.4), participants were instructed to take a reading of their weight on the day of their report, preferably as soon as they got up and while wearing at most some light clothing with no shoes. Participants received a reminder email on the day before their weekly report was due. The email provided a link to the research website of the School with the title of the study and the number of the weekly report due. The completion of the report took participants 15-20 minutes.

8.2.4 Questionnaire instrument

The questionnaire was piloted among three students who provided feedback about the clarity of the descriptions of the patterns of eating and exercise. In addition, participants were asked to report if they had any difficulty in understanding the questions; none did.

The questionnaire's first two items asked for weight either in stones and pounds or in kilograms and for the time and date of that reading of the scales. Next came the timings of the two most recent occasions when the participant carried out each of a set of 12 patterns of eating and exercise (Table 8.1). Participants were told that a good performance in retrieving the timings of episodes when they engaged in particular sorts of eating and exercise would help them to identify activities that contribute to wellbeing.

The question about the timing of the most recent occasion was: *When did you last [pattern description]?* For the timing of the second to last occasion the question was: *When was the occasion before that?* Each question had a box below where the participant entered the timing in the format *hour:minute am/pm, day month year*, for example 12:30 pm, 27 Nov 08. So that participants focused on remembering the occasions of one pattern at a time, each pattern was presented in a section separate from the other patterns. To recall better the timings of each occasion through reconstruction of context, participants were advised to start by remembering where they were and if someone else was present.

Table 8.1 Descriptions of eating and exercise patterns monitored among students.

	Code	Full wording
1	Veg/salad in a meal	Eat vegetables or salad in a meal
2	Fish/meat with little/no fat	Eat fish or meat with little or not fat you could see, e.g. tuna, prawns, chicken, lamb, beef
3	Fruit at a meal	Eat fruit within a meal
4	Meal low in fat	Cut down on fat in a meal
5	Bread start meal	Have bread at the start of a meal which was several hours after the previous meal
6	Calories between meals	Have some calories between meals in a food or drink, e.g. chocolate bar, biscuits, crisps, fruit juice, coke
7	Fruit/salad between meals	Have some fruit or salad item between meals when you wanted something to eat
8	Drink alcohol	Drink some alcohol between meals
9	Walk	Walk outdoors
10	Cycle	Cycle for more than 15 minutes
11	Use stairs	Use stairs rather than lift or escalators
12	Vigorous exercise	Do more than about 30 minutes of vigorous exercise, e.g. jog, swim, fitness class, workout at the gym

8.2.5 Identification of feasible changes in frequency

It was regarded as feasible or an individual to change the frequency of a pattern in a healthier direction if that person's baseline frequency was inside the less healthy quartile of the frequencies observed in the participants thus far. The dietary guidelines then promulgated by the UK Food Standards Agency (now by the NHS) were used to specify the healthy direction, together with the responses in their own words by participants who distinguished between meals perceived as "healthy" or "unhealthy" (Chapter 3). For instance, in the case of the practice of having calories between meals, a healthy change in frequency would be doing it less often than usual.

8.2.6 Request to change frequency

The eligible participant was sent an email proposing a feasible change in a pattern. The wording of the emailed request used the same description of the pattern as in the tracking questionnaire. Participants were informed that, according to their and others' frequencies of all activities, this change should be feasible for them and might be of benefit if they kept it up. They were asked not to change other activities at the same time. If they did not want to make the proposed change, they could ask the researcher for an alternative.

In the event, only one change was proposed to participants in this study - having *calories between meals* less often. All who were asked agreed to make that change.

8.2.7 Analysis

8.2.7.1 Estimates of frequencies from recalled timings

The frequency of each tracked pattern of eating and exercise (Table 8.1) was estimated by dividing seven days by the length of time in days between the most recent occasions reported. This calculation gives the number of times per week in which the pattern was carried out.

8.2.7.2 Lengths of period for baselines of frequency and of weight

The period over which baseline is estimated needs to be as short as possible in order to conserve the number of reports available for measurement of effect on weight. To find the minimum period needed to achieve the lowest variation in a frequency, the variance in individuals' frequencies was determined for each pattern for periods of two, three, four and five consecutive weeks (after any initial changes: see 8.2.7.5 below). As the averaged number of weeks increases, the variance across the group should decrease as result of the improving estimate of each participant's mean frequency. The number of weeks above which there is no

longer a reliable decrease in variance was taken as the minimum period for providing a baseline value. To test if the decreases in variance were an artefact of repeated reporting, the effect on variance of increasing number of weeks was also tested on averages backwards from the fifth week (rather than forwards from the first week).

The same analysis was performed on weight, to find its initial period of lowest variation after a request, i.e. the asymptote of any effect of that request.

8.2.7.4 Threshold for a change in frequency

The difference in frequency of a pattern from one week to the next was calculated. The frequencies were processed if the extent of difference was 25% from one week to other. Two or more consecutive weekly differences in frequency of a pattern in the same direction (i.e., of the same sign) were taken to indicate a change in frequency.

8.2.7.5 Changes in frequency and in weight

Since participants differ in the week when a change occurs, the initial week of a change in frequency of a pattern of eating or exercise was aligned vertically across participants in the database table (in Excel), as also were their weekly body weights. Data for the baseline frequency value were therefore to the left of that line.

The aligned data for each pattern of behaviour monitored were tested for effects on weight of maintained change in frequency of the pattern. First, the variations in weight and frequency of a pattern across the weeks from the mean of the baseline weeks were tested for constancy across participants by repeated-measures analysis of variance (rm-ANOVA) with orthogonal contrasts. Then the associations between difference in frequency from one week to another with the difference in weight over the same period or lagged by one week were assessed using one-predictor linear regression by least squared deviates. The coefficient, β (beta), of this simple regression is the same as the coefficient, *r*, of Pearson's product-moment correlation. However the value of the slope, *b*, of the regression line from frequency to weight differs from the *b* value for the regression through the same data from weight to frequency.

8.2.7.6 Concurrent changes in frequency

The differences in frequency of each pattern of behaviour from week to week over the weeks of change in frequency of the tested pattern were tested for associations by principal components analysis (PCA) with varimax rotation. To check if inter-related patterns with strong loadings (> 0.7) were stable, each PCA was repeated, varying the number of factors to be extracted. If two or more patterns had differences in frequency that loaded above 0.4 into

the same component in two or more week-periods of monitoring, that was taken as evidence of causally related changes in frequency among those patterns. For example, if two verbally distinct patterns of eating might load on the same component from the first to the second week, third to fourth week and fourth to fifth week, these concurrent changes indicate common ("third factor") causation.

8.2.7.7 Causal direction

To test if the direction of causation was from behaviour to weight, the difference in frequency over a period of weeks was correlated with the difference in weight over the same period but started one week later. The inverse direction of causation, from weight to behaviour, was tested by correlating the differences over a period with the frequency change starting one week later. These cross-lagged associations were measured by linear regression too.

Lagged analysis arguably requires the change in frequency to continue after the start in measurement of weight change. If that is so, in circumstances when participants reach the asymptote of frequency change by the time of the first report after the request to change frequency, they need more frequent monitoring.

The effect on weight of the change in frequency is reliable at $p < 0.05$ if the limits of the 95% confidence interval (CI) of the coefficient of correlation/regression (r) are on the same side of zero. The difference between patterns in amount of effect on weight also is reliable if the 95% CIs of their r values do not overlap (when the samples are about the same size and not seriously heteroscedastic).

The sample size needed for detecting reliable effects was calculated using the r-to-z transformation. A sample of 25 participants is sufficient to detect a moderate statistical effect size, e.g. Cohen's $d \geq 0.5$. Fifty participants are needed to detect $r \geq 0.3$ or to distinguish $r = 0.5$ from $r = 0.3$ at $p < 0.05$. To detect $r = 0.25$, over 70 participants are needed. Nevertheless, if change in frequency of a single pattern of behaviour is solely responsible for the change in weight, it is theoretically possible for the observed regression coefficient to approach 1.0. In any case, what matters scientifically and practically is not the above statistical evidence but the actual amount of change in weight for a feasibly maintained change in frequency.

8.2.7.8 Dose-response of change in frequency on weight

The slope (b) of linear regression from change in frequency of a behavioural pattern to a time-lagged change in weight gives the amount of effect on weight of a unit change in

behaviour, such as grams of weight lost per reduction in frequency of once per week in the eating of high-fat foods or walking between campus and home.

If cross-lagged analysis shows the concurrent regression to be dominated by an effect of behaviour on weight, then the (same-signed) concurrent slope over the period from response to asymptote is arguably the best estimate of the amount of weight change for a unit change in frequency. Also the most realistic scientific measure of the effect of the change on weight is the slope of regression over only those who were observed actually to change frequency in the requested direction. Any participant who did not change, or who moved in the opposite direction, is not relevant to a measure of the effectiveness of the request: s/he may not wish to comply or s/he may not understand exactly which habit the request refers to.

8.3 Results

8.3.1 Weeks needed for baseline

In seven out of the 12 monitored patterns, the group variance in frequency decreased as expected with the lengthening of the period over which frequency was averaged (Table 8.2, patterns 2, 6, 7, 8 and 11; Table 8.3, rows 6, 9, 11 and 12). In four of these patterns, the group mean variances over either three or two weeks were reliably lower than those for two weeks or a single week, without any reliable decreases (or increases) in variance for longer periods (Table 8.3, rows 6, 9, 11 and 12).

The one-week or two-week averages always had the numerically greatest variances. The last decrease in variance was at the average of three weeks. Strangely, the group variance in six patterns increased after a decrease (Table 8.2, rows 2, 3, 5, 7, 8 and 10).

In the light of these endings of reliable decreases in variance, a period of three weeks was chosen for averaging into a baseline value of frequency.

8.3.2 Weekly recording of body weight

Although online reporting was nominally once a week, the median interval between reports was eight and a half days. Most participants reported measuring weight on the day of the report on all occasions but two sometimes reported taking their weight the day before.

Participants invariably reported reading their weight in the same period of the day each week. The standard deviation of the reported time of the day of weighing indicated that a third of the participants measured their weights within an hour of a fixed time on every occasion, while a half measured their weight in a range between one and three hours. Only a seventh ranged as far as three to four hours and a mere 2% to four or five hours.

Table 8.2 Variance in frequency of a monitored pattern or in weight averaged over periods of up to 5 weeks from the first week after initial changes. Wk n: week number of the datum. n wk = duration in weeks.

	Pattern or weight	*N*	*Group variance in mean frequency*					*Ratio of variances for durations*			
			Week 1	Wks 1 to 2 mean	Wks 1 to 3 mean	Wks 1 to 4 mean	Wks 1 to 5 mean	1 wk / 2 wk	2 wk / 3 wk	3 wk / 4 wk	4 wk / 5 wk
1	Veg/salad in a meal	43	94	90	127	105	97	1.0	0.7	1.2	1.1
2	Fish/meat with little/no fat	32	116	91	83	87	136	1.3	1.1	1.0	[0.6]
3	Fruit at a meal	30	112	38	49	52	62	2.9**	0.8	0.9	0.8
4	Meal low in fat	44	83	133	86	79	74	[0.6]	1.6^{m}	1.1	1.1
5	Bread start meal	15	7	3	10	7	37	2.3^{m}	[0.3]	1.4	[0.2]
6	Calories between meals	35	1115	1457	712	512	378	0.8	2.0*	1.4	1.4
7	Fruit/salad between meals	22	57	108	46	33	21	[0.5]	2.4*	1.4	1.6
8	Drink alcohol	37	9	219	105	69	48	[0.0]	2.1*	1.5^{m}	1.4
9	Walk	36	1155	2168	1281	1365	1355	[0.5]	1.7^{m}	0.9	1.0
10	Cycle	20	67	61	59	58	127	1.2	1.0	1.0	[0.6]
11	Use stairs	37	69E4	23E4	14E4	10E4	9E4	3.0**	1.5^{m}	1.5	1.1
12	Vigorous exercise	37	6	4	3	3	3	1.5^{m}	1.4	1.0	0.9
13	*Weight*	71	122	122	126	127	127	1.1	0.9	0.9	1.0

Increase in variance at $p < 0.01$. ** $p < 0.01$, * $p < 0.05$, ^{m} $p < 0.1$.

Table 8.3 Variance in frequency or weight averaged over periods of up to 5 weeks from the fifth week after initial changes back to the first week.
Wk n: week number of the datum. n wk = duration in weeks.

	Pattern	*N*	*Group variance in mean frequency*					*Ratio of variances for durations*			
			Week 5	Wks 4 & 5 mean	Wks 3 to 5 mean	Wks 2 to 5 mean	Wks 1 to 5 mean	1 wk / 2 wk	2 wk / 3 wk	3 wk / 4 wk	4 wk / 5 wk
1	Veg/salad in a meal	43	176	212	171	123	97	0.8	1.2	1.4	1.3
2	Fish/meat with little/no fat	32	880	90	229	173	136	9.8**	[0.4]	1.3	1.3
3	Fruit at a meal	30	174	50	110	72	62	3.5**	[0.5]	1.5	1.2
4	Meal low in fat	44	162	124	118	97	74	1.3	1.1	1.2	1.3
5	Bread start meal	15	789	16	93	55	37	51.0**	[0.2]	1.7	1.5
6	Calories between meals	35	109	1102	153	423	378	[0.1]	7.2**	0.4	1.1
7	Fruit/salad between meals	22	14	55	11	22	21	[0.3]	5.2**	[0.5]	1.0
8	Drink alcohol	37	6	230	13	72	48	[0.0]	17.0**	[0.2]	1.5
9	Walk	36	3239	1535	2021	1560	1355	2.1*	0.8	1.3	1.2
10	Cycle	20	67	55	54	54	94	7.6**	[0.4]	1.2	1.1
11	Use stairs	37	14E4	15E4	8E4	10E4	9E4	0.9	1.8*	0.9	1.1
12	Vigorous exercise	37	10	4	4	4	3	2.9**	0.8	1.2	1.2
13	*Weight*	71	129	122	126	127	127	1.0	0.9	0.9	1.0

Increase in variance at $p < 0.01$. ** $p < 0.01$, * $p < 0.05$, ^{m} $p < 0.1$.

The range of variation in recorded weight from week to week was a whole one or two pounds in most cases. This indicates that scales were marked in pounds or that participants rounded to the nearest unit. The variations from one week to the next were not directional overall: out of 587 cases, weight increased in 52% and decreased in 48%. This finding indicated no general increase or decrease in weight. It also showed that participants did not round the reading on the scales predominantly towards a lower weight. Moreover, the group variance of the weight did not increase or decrease reliably over the weeks of monitoring, indicating a constant precision of reading and recording (Tables 8.2 and 8.3, line 13).

8.3.3 Variations in change of frequency

The mean week-to-week differences in frequency of low-fat meals among successive periods during the monitoring without a request to change anything (Table 8.4, row 4). Similarly, the mean weekly differences in frequency of having salad or vegetables in a meal differed marginally after the third week (Table 8.4, row 1, linear trend).

8.3.4 Covariations in change of frequency

In four out of the eight differences between weekly frequencies, low-fat meals loaded heavily or moderately in the same component with salad or vegetables in a meal (Table 8.5, weeks 1-2, 4-5, 5-6 and 6-7). These components accounted for 19-14% of the variance. Such changes in parallel are consistent with healthy eating practices that were recognised locally in a sample more diverse in age (Chapter 4). Moreover, a change in frequency of consumption of low-fat foods could affect the rate of energy exchange through the physiological mechanism of fat's greater energetic efficiency (1.7.1.1). So the effect on weight of an unrequested increase in frequency of low-fat meals was investigated.

Vigorous exercise co-loaded with cycling in early weeks (Table 8.5, weeks 2-3 and 3-4). Hence, unrequested change in the more general category of movement was also analysed.

Table 8.4 Frequency and weight differences between one week and the next over successive weeks from the recruitment session to the fifth report during monitoring. W0 = Week of recruitment. W1 to W5 = weeks of Reports 1 to 5.

	Pattern		Mean of differences in frequency between successive weeks (W)					rmANOVA		Linear		Quadratic		Cubic		Quartic	
		N	W1-W0	W2-W1	W3-W2	W4-W3	W5-W4	η_p^2	*F*	η_p^2	*F*	η_p^2	*F*	η_p^2	*F*	η_p^2	*F*
1	Veg/salad in a meal	*71*	-1.4	2.5	2.7	-1.2	2.5	0.01	0.7	0.00	0.3	0.00	0.3	0.04	3.0^m	0.00	0.2
2	Fish/meat with little/no fat	*66*	-0.6	2.7	0.2	1.1	1.6	0.00	0.2	0.00	0.2	0.00	0.0	0.00	0.3	0.00	0.3
3	Fruit at a meal	*54*	0.9	36.0	-35.0	-0.8	-1.5	0.02	0.9	0.02	0.8	0.02	0.8	0.02	0.9	0.02	0.9
4	Meal low in fat	*71*	3.7	2.2	-1.3	0.8	-2.2	0.02	1.4	0.12	9.1**	0.00	0.1	0.00	0.2	0.01	0.8
5	Bread start meal	*22*	0.9	-1.5	1.3	53.0	-54	0.06	1.4	0.06	1.4	0.07	1.5	0.06	1.3	0.06	1.3
6	Calories between meals	*77*	23.0	-20.0	-2.7	-6.9	2.0	0.01	0.9	0.02	1.7	002	1.6	0.01	0.5	0.01	0.9
7	Fruit/salad between meals	*56*	-0.6	6.1	-8.9	1.4	-.82	0.02	0.9	0.00	0.2	0.01	0.3	0.01	0.3	0.03	1.5
8	Drink alcohol	*57*	-2.0	3.9	-0.1	-4.5	0.6	0.01	0.8	0.00	0.2	0.00	0.1	0.05	3.0^m	0.00	0.0
9	Walk	*70*	-9.2	15.5	6.3	-9.1	-8.4	0.02	1.4	0.03	1.7	0.03	2.3	0.05	3.6^m	0.00	0.0
10	Cycle	*21*	0.7	-1.0	0.7	-0.1	0.6	0.00	0.1	0.00	0.0	0.00	0.0	0.01	0.1	0.04	0.8
11	Use stairs	*57*	157.0	-73.0	29.0	-54.0	35	0.02	1.4	0.07	4.1*	0.04	2.6	0.01	0.3	0.03	1.5
12	Vigorous exercise	*47*	0.6	-0.1	-0.0	4.5	-4.6	0.03	1.6^m	0.05	2.6	0.03	1.4	0.04	1.8	0.03	1.4

^{m} $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

Table 8.5 Loadings onto the first two principal components (C1, C2) of differences between weekly frequencies from the recruitment session W0 to the seventh week of monitoring, W7, for each customary pattern. Loadings greater than or equal to |0.7| are in bold font and |0.5| in italics.

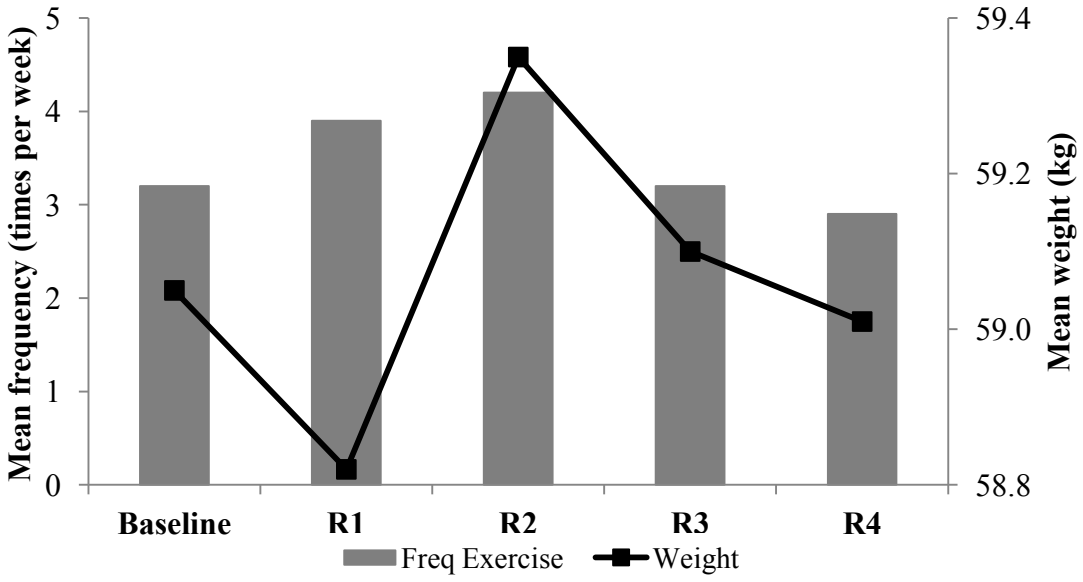
Pattern	Loadings for each period															
	W0 - W1 (*N* = 92)		W1 - W2 (*N* = 80)		W2 - W3 (*N* = 80)		W3 - W4 (*N* = 79)		W4 - W5 (*N* = 79)		W5 - W6 (*N* = 78)		W6 - W7 (*N* = 78)		W7 - W8 (*N* = 77)	
	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
1 *Veg/salad in a meal*	0.4	-0.2	-0.1	**0.9**	-0.3	**0.7**	0.1	*0.5*	**0.8**	0.3	**0.8**	0.1	**0.9**	-0.1	0.2	0.2
2 Fish/meat with little/no fat	0.2	*0.5*	-0.1	*0.5*	-0.3	0.1	**0.9**	0.0	0.2	**0.7**	*0.6*	0.1	*0.5*	0.0	0.0	0.0
3 Fruit at a meal	0.1	-0.2	0.0	-0.1	0.0	0.1	**0.8**	-0.1	0.1	*0.6*	**0.7**	-0.2	-0.1	0.4	0.4	*-0.6*
4 *Meal low in fat*	0.3	-0.1	0.0	0.4	0.0	0.1	-0.1	0.0	*0.6*	0.0	**0.8**	0.1	**0.8**	0.1	*0.6*	0.1
5 Bread start meal	0.3	0.4	0.1	0.1	0.0	**0.7**	0.0	0.4	0.2	0.0	*0.4*	0.0	0.0	0.2	-0.4	0.3
6 Calories between meals	0.2	0.0	0.0	**-0.7**	-0.1	-0.2	-0.1	*-0.6*	-0.1	0.4	0.1	-0.1	0.2	*0.5*	*-0.5*	0.0
7 Fruit/salad between meals	*0.6*	0.2	**0.7**	0.0	**0.8**	-0.3	0.0	0.4	0.0	-0.2	-0.1	*0.4*	0.1	*0.5*	*0.5*	0.1
8 Drink alcohol	-0.1	*0.4*	0.1	-0.1	0.0	*-0.6*	0.1	-0.2	*0.6*	-0.2	0.2	0.3	0.1	0.2	0.4	0.1
9 Walk	-0.1	*0.5*	*0.4*	-0.1	0.2	-0.2	-0.1	0.4	0.0	*-0.5*	-0.2	0.7	-0.1	*0.6*	*0.5*	0.0
10 Cycle	*-0.6*	0.0	**0.9**	0.1	**0.9**	0.1	**-0.9**	0.0	0.0	0.0	0.0	0.3	0.4	0.0	-0.3	0.1
11 Use stairs	0.0	*0.4*	*0.5*	0.3	**0.7**	0.1	-0.1	*-0.6*	0.1	-0.4	0.0	*0.5*	-0.1	*-0.6*	0.0	**0.7**
12 Vigorous exercise	*-0.5*	0.3	**0.9**	0.0	**0.9**	0.1	0.1	0.2	**-0.8**	0.1	0.0	*0.6*	0.0	*0.4*	0.2	**0.7**
Percent of variance explained	*11*	*11*	*20*	*14*	*24*	*13*	*20*	*12*	*19*	*14*	*19*	*12*	*16*	*14*	*14*	*13*

8.3.5 Unrequested increase in frequency of *vigorous exercise*

Changes in group means. During the monitoring period before any request to change a pattern's frequency, 13 participants showed two successive numerical increases above baseline in frequency of *more than about 30 minutes of vigorous exercise* (Figure 8.1). However, this greater mean frequency was followed by smaller frequencies, down to the baseline mean value. Yet the mean frequency values did not vary reliably over five weeks, nor did a quadratic contrast approach (analysis not shown). Nevertheless, these means were the only sign of changes in frequency of a movement habit in this study and so the data are considered further, at least as an illustration of the logic of causal analysis.

Week-to-week variations in mean weight were no more than half a kilogram but the data provided opportunities to construct testable hypotheses about effects of frequency change on weight (Figure 8.1). After a slight decrease in mean weight from baseline to the first report, there was a considerable increase to the second report. Thereafter mean weight decreased over the third and fourth reports to the baseline value. Since that decline followed the peak in mean frequency, one possibility is that sufficient increase in vigorous exercise caused some loss in weight in the subsequent week.

Figure 8.1 Group means (N = 13) of unrequested changes in frequency of ***more than about 30 minutes of vigorous exercise*** (columns, with scale on the left) and concurrent change in weight (line of squares, with scale on the right).



An additional possibility is that the initial decrease in weight encouraged an increase in vigorous exercise coupled with additional eating and so a relatively sharp increase in weight. Distinct causal processes could operate in different people, or simultaneously or consecutively in the same person. Such possibilities may be demonstrated by co-variances across the group between the sizes of individuals' changes in frequency and weight.

Regressions across individuals. Amounts of change in frequency and weight each week (differences between consecutive reports) gave very low correlation coefficients (Table 8.6, *r*). The 95% confidence limits on each of these correlations lay on either side of zero, showing that their values are far from reliable (Table 8.6, CLs). Nevertheless, except for the last week (when both means changed least), the sign of the coefficient was negative, i.e. an increase in frequency of vigorous exercise went with a decrease in weight, in accord with the simplest hypothesis from energy exchange. This association across individuals during the second week was opposite in sign to that for the group means (Figure 8.1); this observation illustrates the fact that covariances and means are separate parts of the data.

As to be expected, the largest negative correlation went with the steepest negative slope of the regression from frequency change to weight change between the first and second reports (Table 8.6, row 2, *r* and *b*). This slope corresponds to a weight loss of 118 g from a frequency change of once per week (Table 8.6, row 2, *b*). This effect was produced by a rise in mean frequency from about three to four times per week (Figure 8.1).

Time-lagged correlations require data from at least two successive weeks. The phase of rising mean frequency, from baseline to the second report, was considered separately from the falling phase in means, from second to fourth reports (Table 8.6, rows 5 and 6; Table 8.7).

Over the initial two-week period (Table 8.6, row 5), the coefficient (*r*) and slope (*b*) of the regression from frequency change to weight change remained negative, consistently with the hypothesis that vigorous exercise reduced weight (unlike the group means from baseline to the second report, Figure 8.1).

Lagged regressing, from individuals' two-week frequency changes to their weight changes over the second week alone, indicated a lower coefficient (Table 8.7, row 1, left-hand columns of data, *r*).

In contrast, the cross-lagged regression, from weight change over the two weeks to behaviour change in only the second week, gave a much higher coefficient. Thus, the difference between the lagged coefficients indicated that weight change is not caused by frequency change, but the other way round (-0.36 minus -0.09 equals -0.27).

Table 8.6 Regressions from frequency change to weight change for one- or two-week periods during an unrequested increase in **vigorous exercise** (see Figure 8.1). R0: baseline (mean of the three prior reports). R1, R2, R3, R4: consecutive weekly reports.

	Con-current period	CLs of *r*			
		r	low	high	*b*
1	R0-R1	-0.02	-0.53	0.50	-0.004
2	R1-R2	-0.24	-0.67	0.31	-0.118
3	R2-R3	-0.19	-0.64	0.36	0.050
4	R3-R4	0.21	-0.44	0.72	0.058
5	R0-R2	-0.16	-0.62	0.38	-0.074
6	R2-R4	0.06	-0.47	0.56	0.007

Table 8.7 Time-lagged correlations between changes in weight and a rise (baseline to second report) or a fall (second to fourth reports) in the group mean frequency of **vigorous exercise** over four weekly reports (R1, R2, R3 and R4) from the start of an increase in frequency from baseline (R0). *r* = correlation coefficient. CL = 95% confidence limits of *r*.
b = slope for weight change in kilograms per change in frequency of once a week.

			Behaviour to lagged weight				Weight to lagged behaviour			
	Pre-dictor period	Time-lagged period	CLs of *r*				CLs of *r*			
			r	low	high	*b*	*r*	low	high	*b*
1	R0-R2	R1-R2	-0.09	-0.58	0.44	-0.056	-0.36	-0.73	0.19	-1.016
2	R0-R1	R1-R2	0.17	-0.37	0.63	0.084	-0.03	-0.53	0.49	-0.113
3	R2-R4	R3-R4	-0.02	-0.53	0.50	-0.004	0.10	-0.43	0.59	1.073
4	R2-R3	R3-R4	0.18	-0.37	0.63	0.043	0.20	-0.34	0.65	0.886

Lagged regression from the first week to the second week provided no evidence of an effect of behaviour change on weight change (Table 8.7, row 2). Indeed, the coefficient was positive, indicating a fattening effect of increased frequency in vigorous exercise.

In the falling phase of the group means of frequency and weight (Figure 8.1), the concurrent and lagged regressions also pointed to an association at the individual level which was the opposite to that in the grouped data. Changes over the third and fourth weeks correlated positively, not negatively (Table 8.6, row 6).

Regression from this later two-week change in frequency to the last week's change in weight gave a very small negative correlation coefficient (Table 8.7, row 3). Furthermore, the cross-lagged coefficient and slope indicated a considerably stronger effect of individuals' weight increases on the vigorous exercise, doing it less often, and/or, perhaps less understandably, weight decrease (like the means) increasing exercise.

Also, when changes in the third week were regressed onto changes in the fourth week, the signs of the coefficients and slopes were consistent with a weight gain effect of vigorous exercise at a week's delay, although at the same time a delayed effect also of weight gain on the exercise, increasing its frequency (Table 8.6, row 6; Table 8.7, row 4).

8.3.6 Unrequested increase in frequency of a *meal low in fat*

Changes in group means. At least two consecutive weeks with a numerical increase in estimated frequency of low-fat meals were found during monitoring in 13 out of the 79 participants. The first weekly reports in that sequence (R1) were aligned across these participants, for analysis of the weekly frequencies and weights during and after the numerical change in how often such a meal was eaten (Figure 8.2). The selection and alignment gave a highly reliable variation in mean frequencies across six successive reports (Table 8.8, repeated-measures ANOVA), including the report the week before the start of the increase (R-). A consequence of this criterion of selection was that the mean of frequency increased numerically from one week to the next in the two reports following the selected initial report (Figure 8.2, R1 to R3), with R4 and R5 also slightly above R1 and R2. The frequency in subsequent reports, particularly R3, was sufficiently above the start of the rise (R1) and its predecessor (R-) for there to be a reliable linear trend (Table 8.8, linear orthogonal contrast).

Consistently with the hypothesised energy efficiency of deposition of dietary fat (1.7.1.1), the highest mean frequency of low-fat meals (R3) coincided with a drop in mean weight by half a kilogram, which continued for the subsequent two weeks (Figure 8.2, R4 and R5). Nevertheless, the variation in each of the two sets of means was unreliable in repeated-

Figure 8.2 Group means (N = 13) of the frequency of a ***Meal low in fat*** (columns) and of body weight (line of squares) in weekly reports aligned at the start (R1) of at least two successive numerical increases in frequency. R-: mean of individuals' frequencies or weights in the report before R1.

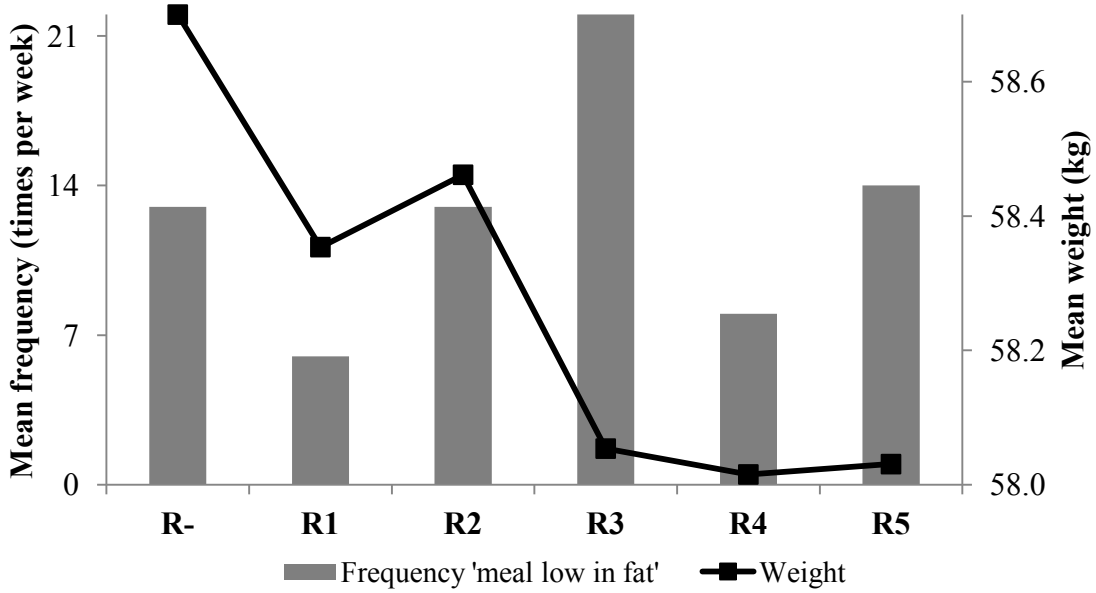


Table 8.8 Analyses of variance with orthogonal contrasts of frequencies of **low-fat meals** and of weight across reports R- to R5 in Figure 8.2.

	Mean at each Report (Rn)						rmANOVA		
	R-	R1	R2	R3	R4	R5	η_p^2	F	$p <$
Frequency (times per week)	13	6	13	22	8	14	0.31	5.4	**0.01**
Weight (kg)	58.7	58.4	58.5	58.1	58.0	58.0	0.04	0.6	0.70

	Linear			Quadratic			Cubic			Quartic		
	η_p^2	F	$p <$	η_p^2	F	$p <$	η_p^2	F	$p <$	η_p^2	F	$p <$
Freq. (tpw)	0.28	4.8	*0.05*	0.30	5.1	*0.04*	0.21	3.3	0.10	0.40	8.1	*0.02*
Weight (kg)	0.05	0.6	0.45	0.03	0.0	0.84	0.12	1.4	0.26	0.05	0.6	0.46

measures ANOVA and its orthogonal contrasts (Table 8.8). That is expected from the small size of the sample and the narrow range of variation in the means of body weight - barely 0.7 kg in weights of nearly 60 kg (Figure 8.2). Moreover, the *F* ratios were considerably less than unity, which may be a sign of heteroscedastic weight values.

Regressions across individuals. The more that a person's frequency of a *meal low in fat* increases, the greater should be the decrease in weight, on the fairly plausible assumptions that low-fat meals replace meals higher in fat content and are not substantially greater in content of energy (because they are bulkier). That is, on this hypothesis, individuals' changes in frequency of low-fat meals would correlate negatively across the group with their changes in weight.

Unasked increase in frequency of *meals that are low in fat* was numerically associated with weight loss over two weeks (Table 8.9, line 5). A causal direction from behaviour to weight was supported by a reliable association of frequency change from the baseline to the first next week with weight change from the first to the second week which was stronger than the association of weight change from the baseline to the first week with change in frequency from the first to the second week (Table 8.10, line 2).

Furthermore, correlation between changes in frequency and weight was substantially negative for the entire period (Table 8.9, line 7). The main hypothesis was supported in the series of reports from time-lagged analyses for direction of causation. As it happens, a slimming effect of more frequent eating of a *meal low in fat* was indicated by the regression from frequency change to lagged effect in the start of weight change data when the period of change included the last week's change (R5, lines 5 and 6 in Table 8.10, left-hand columns).

Amount of weight lost. Clearer support for a slimming effect of meals perceived to be low in fat emerged from regressions in which the predicting change does not overlap in time with the predicted change (Table 8.10, lines 2, 5 and 6). Those regressions from a change in behaviour that ends when the calculated weight change begins all had negative coefficients (*r* values in the left-hand set of columns). The slopes of the regression corresponded to a weight loss in the region of 20-75 g from an extra low-fat meal each week (left-hand *b* values). Reverse causation was considerably weaker and varied in sign among regressions (right-hand *r* and *b* values). The signs of the confidence limits on those *r* values supported these conclusions.

Table 8.9 Regressions from **low-fat meal** frequency change to weight change for periods of one to three weeks from the start of an unrequested increase in frequency of the low-fat meals (see Figure 8.2). R1, R2, R3, R4 and R5: consecutive weekly reports. *N* = 13.

	Con-current period	CLs of *r*			
		r	low	high	*b*
1	R1-R2	0.09	-0.45	0.57	0.009
2	R2-R3	0.26	-0.29	0.68	0.027
3	R3-R4	0.41	-0.13	0.76	0.020
4	R4-R5	-0.36	-0.73	0.19	-0.026
5	R1-R3	-0.18	-0.63	0.37	-0.014
6	R1-R4	0.73	0.34	0.90	0.15
7	R1-R5	-0.52	-0.82	-0.01	-0.87

Table 8.10 Time-lagged correlations between changes in frequency of **low-fat meals** and changes in weight over five weekly reports (R1, R2, R3, R4 and R5). *r* = correlation coefficient. CL = 95% confidence limits of *r*. *b* = slope for weight change in kilograms per change in frequency of once a week. *N* = 13.

	Pre-dictor period	Time-lagged period	Behaviour to lagged weight				Weight to lagged frequency			
			CLs of *r*				CLs of *r*			
			r	low	high	*b*	*r*	low	high	*b*
1	R1-R3	R2-R3	-0.12	-0.60	0.42	-0.011	0.12	-0.42	0.60	1.13
2	R1-R2	R2-R3	-0.56	-0.83	-0.07	-0.078	-0.17	-0.62	0.38	-1.99
3	R1-R4	R2-R4	0.49	-0.04	0.80	0.108	0.73	0.36	0.91	7.91
4	R1-R3	R3-R4	-0.51	-0.81	0.01	-0.031	0.26	-0.29	0.68	4.33
5	R1-R5	R2-R5	-0.21	-0.65	-0.34	-0.020	0.11	-0.43	0.59	0.65
6	R1-R3	R3-R5	-0.62	-0.86	-0.16	-0.066	-0.35	-0.73	0.20	-5.23

8.3.7 Unrequested increase in frequency of *vegetables or salad in a meal*

In principal components analysis of frequency changes, low-fat meals did not generally load with any other pattern onto the same component (Table 8.5 above, row 4).

However, from weeks 4 to 7, there was some confounding by meals that included vegetables or salad (Table 8.5, row 1).

The mean across participants of the frequency of meals with vegetables or salad increased marginally during the period when low-fat meals were increasing in frequency (Table 8.4 above, rows 1 and 4). Hence meals with vegetables or salad are also considered alongside the above causal analysis of weight and meals perceived to be *low in fat*.

Changes in group means. Meals with vegetables or salad recalled in the reports selected for unasked increase in frequency of low-fat meals showed a slight numerical increase in group mean frequency from the first to second reports (Figure 8.3). However, unsurprisingly, this increase was not sustained in the second week as it was with low-fat meals when the third report was used in the selection criterion (Figure 8.3). Group mean frequency of veg./salad meals decreased in subsequent reports in this alignment, particularly clearly at the fourth report, as with low-fat meals (Figures 8.2 and 8.3, R4). Furthermore there was some evidence of three inflections (two troughs or peaks) in the mean frequencies: overall variation was not reliable but a quartic contrast was, with some sign of a linear trend downwards too (Table 8.11).

Group mean weight values lay on a clear line downwards (Figure 8.3). However the weight data were too far from normally distributed to give evidence of a linear trend (Table 8.11). An association of linear trends of means in the same direction for frequency and weight interpreted causally is against the hypothesis that veg./salad in meals reduce weight. Indeed, the greatest week-to-week decline in weight preceded that for frequency. A simple causal interpretation is that a decline in weight made salad seem less necessary.

Regression across individuals. Nearly all the concurrent and time-lagged regression coefficients were very low and shown by confidence limits of opposite sign to be far from reliably different from zero (Tables 8.12 and 8.13). The highest and most nearly reliable coefficient was positive (Table 8.12, row 1, R1-R2), against hypothesis, but was not explained by any lagged regression with the next week (Table 8.13, rows 1 and 2). Hence there was no evidence in these limited data that salad or vegetables in meals affect weight. Certainly any confounding of changes between this habit and a *meal low in fat* is unlikely to account for any evidence that these participants provided for an effect of low-fat meals on weight.

Figure 8.3 Frequency of the pattern ***vegetables or salad in a meal*** (columns) and body weight (squares) over weeks of reports (R1-R5) that indicated an unasked-for rise in frequency of a *meal low in fat*. R1: end of baseline period.

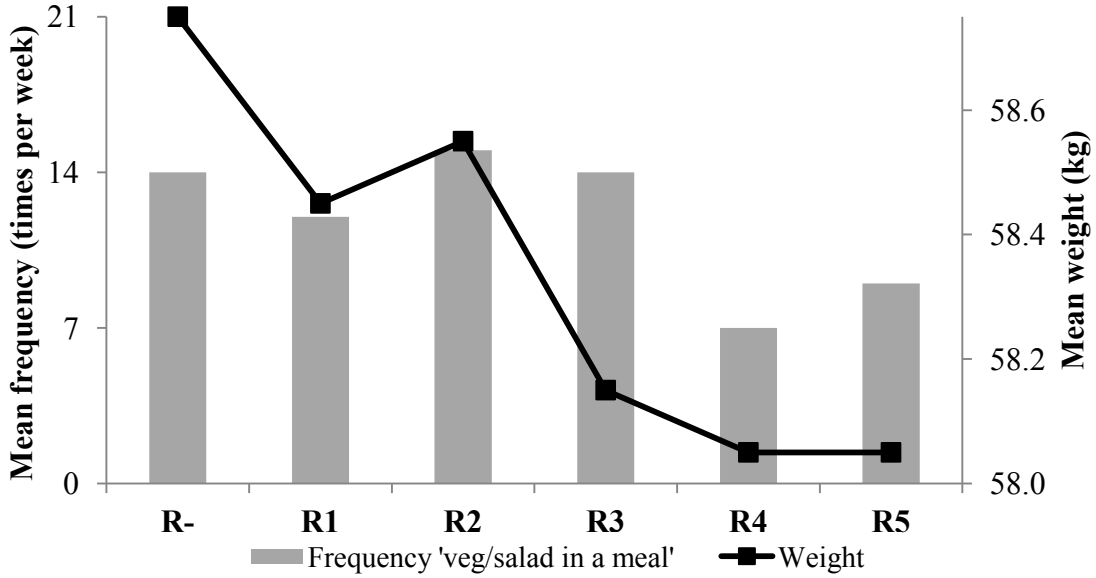


Table 8.11 Analyses of variance with orthogonal contrasts in frequency of a **meal with vegetables or salad** in weight across consecutive weekly reports during the unrequested rise in frequency of low-fat meals. $N = 13$.

	Mean at each Report (R)						rmANOVA		
	R-	R1	R2	R3	R4	R5	η_p^2	F	$p <$
Frequency (tpw)	14	12	15	14	7	9	0.12	1.5	0.21
Weight (kg)	58.7	58.4	58.5	58.1	58.0	58.0	0.04	0.6	0.70

	Linear			Quadratic			Cubic			Quartic		
	η_p^2	F	$p <$	η_p^2	F	$p <$	η_p^2	F	$p <$	η_p^2	F	$p <$
Freq. (tpw)	0.22	3.4	0.09	0.09	1.2	0.30	0.01	0.1	0.76	0.30	5.1	**0.04**
Weight (kg)	0.05	0.6	0.45	0.03	0.0	0.84	0.12	1.4	0.26	0.05	0.6	0.46

Table 8.12 Regressions to weight change from frequency change of a **meal with salad or vegetables** for periods of one to four weeks (see Figure 8.4). R1: report of end of baseline. R1, R2, R3, R4 and R5: consecutive weekly reports. *r* = correlation coefficient. CL = 95% confidence limits of *r*. *b* = slope for weight change in kilograms per change in frequency of once a week. *N* = 13.

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	Con-current period	*r*	CLs of *r* low	high	*b*
1	R1-R2	0.47	-0.05	0.79	0.036
2	R2-R3	0.10	-0.43	0.58	0.007
3	R3-R4	-0.23	-0.66	0.32	-0.014
4	R4-R5	-0.13	-0.60	0.41	-0.043
5	R1-R3	0.14	-0.40	0.61	0.012
6	R1-R4	0.16	-0.39	0.62	0.016
7	R1-R5	0.20	-0.35	0.64	0.034

Table 8.13 Time-lagged correlations between changes in frequency of ***vegetables or salad in a meal*** and changes in weight over five weekly reports (R1, R2, R3, R4 and R5). *r* = correlation coefficient. CL = 95% confidence limits of *r*. *b* = slope for weight change in kilograms per change in frequency of once a week. *N* = 13.

	Pre-dictor period	Time-lagged period	Behavior to lagged weight				Weight to lagged behaviour			
				CLs of *r*				CLs of *r*		
			r	low	high	*b*	*r*	low	high	*b*
1	R1-R3	R2-R3	-0.14	-0.61	0.40	-0.010	0.11	-0.43	0.59	1.25
2	R1-R2	R2-R3	-0.03	-0.53	0.49	-0.002	-0.30	-0.70	0.25	-5.66
3	R1-R4	R2-R4	-0.06	-0.56	0.47	-0.006	0.16	-0.39	0.62	1.48
4	R1-R3	R3-R4	0.05	-0.47	0.55	0.004	0.16	-0.38	0.62	2.08
5	R1-R5	R2-R5	-0.16	-0.62	0.38	-0.094	0.20	-0.35	0.65	2.01
6	R1-R3	R3-R5	0.29	-0.26	0.70	0.035	0.21	-0.34	0.65	2.63

8.3.8 Requested decrease in frequency of *calories between meals*

A total of 26 participants agreed to consume calories between meals less often; 23 of these returned at least two weekly reports after the request.

8.3.8.1 Effect of observed frequency change on weight

Changes in group means. Fourteen of the participants decreased frequency of between-meal calories in two consecutive weeks (Figure 8.4) – the minimum period for time-lagged analysis. Because of the selection for successive decreases, this variation among mean frequencies was highly reliable despite the small size of the group (Table 8.14, row 1). The linear trend visible in the graph was marginally reliable (Table 8.14, row 1). The effect sizes were moderately large too.

The means of weight recorded weekly also went down linearly after the request to decrease in frequency of calories between meals (Figure 8.4). However, neither this overall variation nor the linear trend achieved reliability (Table 8.14, row 2).

Figure 8.4 Mean frequency of **between-meal calories** (columns) and weight (squares) after a request to eat calories between meals less often ($N = 14$).

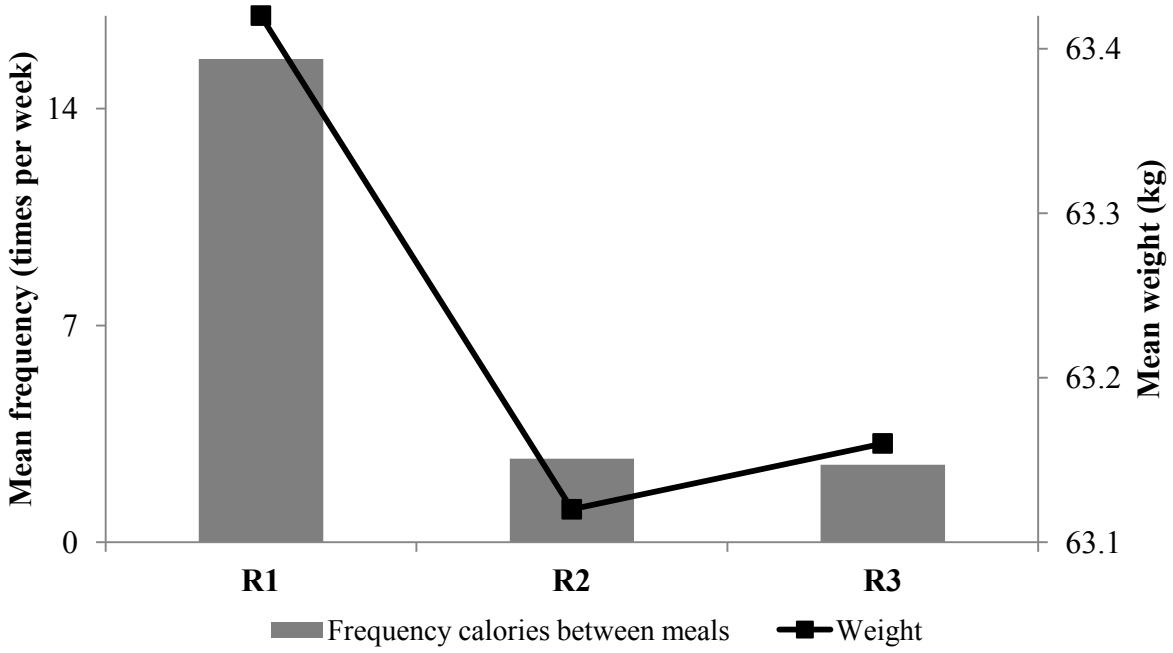


Table 8.14 Repeated measures analysis, with orthogonal contrasts, of the variations in frequency of **between-meal calories** and in weight read off balances in reports from fourteen participants who complied with the request to eat *calories between meals less often*.

Measure	Mean at each Report (R)			rmANOVA		Linear		Quadratic	
	R1[a]	R2	R3	η_p^2	*F*	η_p^2	*F*	η_p^2	*F*
1 Frequency (tpw [b])	15.6	2.7	2.5	0.60	19.1**	0.61	20.3*	0.55	16.3*
2 Weight (kg)	63.4	63.1	63.1	0.06	0.9	0.06	0.8	0.07	1.0

[a] baseline before request = mean of the two prior reports

[b] tpw = times per week, * $p < 0.001$.

Regressions across individuals. In the event, almost all the regression coefficients, both concurrent (Table 8.15, rows 2 and 3) and lagged (Table 8.16, rows 1 and 2), were small but they had a positive sign. This supported the main hypothesis that weight is reduced by fewer occasions of calories between meals (2.7.2). The calories specified in this experiment were *snackfoods and calorific drinks.* Critically, the decrease in this eating pattern was associated with weight loss starting after a lag (Table 16, rows 1 and 2).

The regression coefficients for lagged weight and lagged frequency were similar (Table 8.16 rows 1 and 2). However, the change in frequency was requested and so it is unlikely to be entirely attributable to a perceived change in weight.

Table 8.15 Concurrent correlations of requested reduction in frequency of **between-meal calories** and change in weight ($N = 14$).

	Con-current period	CLs of *r*			
		r	low	high	*b*
1	R1-R2	-0.04	-0.52	0.47	-0.002
2	R2-R3	0.29	-0.24	0.69	0.123
3	R1-R3	0.13	-0.39	0.58	0.012

Table 8.16 Time-lagged regressions of requested reduction in frequency of **between-meal calories** and change in weight ($N = 14$).

	Pre-dictor period	Time-lagged period	Behaviour to lagged weight				Weight to lagged behaviour			
				CLs of *r*				CLs of *r*		
			r	low	high	*b*	*r*	low	high	*b*
1	R1-R3	R2-R3	0.14	-0.38	0.60	0.011	0.33	-0.19	0.71	1.03
2	R1-R2	R2-R3	0.29	-0.24	0.69	0.007	0.43	-0.08	0.76	0.80

Amount of weight lost with fewer calories between meals. The slope of the regression (*b*) indicated that a decrease of once per week in consumption of calories between meals reduced weight by 12 g from the baseline to the following two weeks (Table 8.15, row 3). A similar lagged effect on weight over two weeks by fewer between-meal calories was estimated (Table 8.16, rows 1 and 2).

8.3.8.2 Effect of the request on weight

The effect of the request to eat calories between meals less often can be evaluated in the whole set of 22 participants (excluding an outlier in frequency) without selection with regard to direction or time-course of individuals' changes in frequency.

Changes in group means. The dispersions of frequencies and weights at each report were too great to give reliable overall variation in means (Table 8.17, column for rmANOVA). Nevertheless, there were reliable linear and quadratic orthogonal contrasts in the group means of frequency (Table 8.17, row 1). These trends are clear graphically as a decrease in mean frequency from the report before the request (R1) to the two subsequent weekly reports (R2 and R3), combined with a slight increase from the second to the third report accounting for the quadratic (Figure 8.5).

In line with prediction, the mean weight decreased in parallel with that requested decrease in frequency of calories between meals (Figure 8.5). However, neither the overall variation in mean weights nor any contrast was statistically significant (Table 8.17, row 2).

Figure 8.5 Mean frequency of between-meal calories (columns) and weight (squares) after a request to ***eat calories between meals less often*** (*N* = 22).

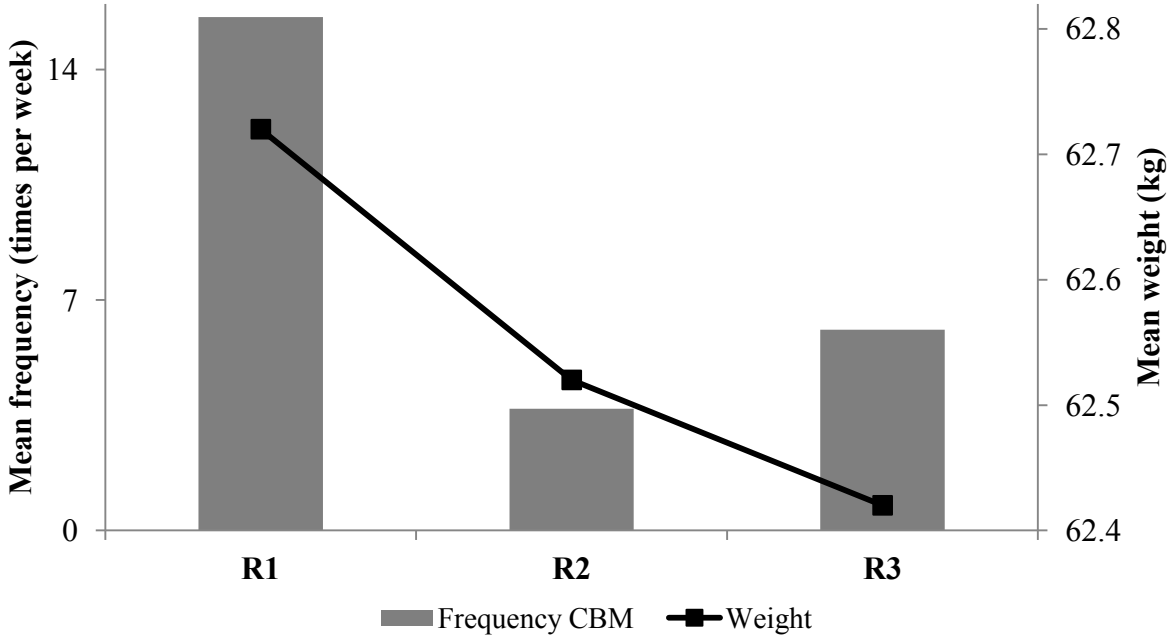


Table 8.17 Repeated measures analysis, with orthogonal contrasts, of the variation in frequency of between-meal calories and in weight read off balances in reports from participants who received request to ***eat calories between meals less often*** (*N* = 22).

Measure	Mean at each Report (R)			rmANOVA		Linear		Quadratic	
	R1[a]	R2	R3	η_p^2	*F*	η_p^2	*F*	η_p^2	*F*
1 Frequency (tpw [b])	15.6	3.7	6.1	0.42	15.1	0.41	14.8*	0.42	15.7*
2 Weight (kg)	62.7	62.5	62.4	0.06	1.2	0.07	1.5	0.02	0.3

[a] baseline before request = mean of the two prior reports.

[b] tpw = times per week, * $p < 0.001$.

Regressions across individuals. When the effects of the request to reduce the frequency of calories between meals were tested by linear regression, there were no reliable relationships between changes in frequency and in weight. Nevertheless the numerical patterns in strength of association and direction of changes can be used to illustrate the potential diagnostic power of this approach.

The signs of the concurrent correlations indicated that, at the individual level, frequency and weight generally changed in the same direction from the baseline to the subsequent weekly report (R1-R2; Table 8.18, row 1) and also from the baseline to the last weekly report (R1-R3, row 3) but not within the second week after request (R2-R3, row 2). Indeed, a very small inverse association was found in the second week. This might be related to the small increase in mean frequency in that week (Figure 8.5).

The lagged regressions from frequency change in the first week to weight change in the second week (Table 8.19, row 2) and from frequency change over both weeks to weight change in the second week had also slightly negative slope (row 1). These results opposite to the hypothesis could illustrate a confounding effect from mixing in the causal analysis participants who maintained and not maintained the asked change.

Amount of weight lost. The positive slopes (*b*) in the regressions in the period after the request (R1 to R2) indicated that decrease in frequency was concurrent with weight reduction and that this effect may have continued into the subsequent period (R3). The values of the slopes give an estimated decrease in weight of a decrease of once per week of calories between meals ranges from 9 to 12 g (Table 8.18, rows 1 and 3; Table 8.19, row 2).

Table 8.18 Concurrent correlations of requested reduction in frequency of **between-meal calories** and change in weight ($N = 22$).

	Con-current period		CLs of *r*		
		r	low	high	*b*
1	R1-R2	0.17	-0.25	0.53	0.009
2	R2-R3	-0.01	-0.41	0.40	- 0.001
3	R1-R3	0.13	-0.29	0.51	0.012

Table 8.19 Time-lagged regressions of requested reduction in frequency of **between-meal calories** and change in weight ($N = 22$).

	Pre-dictor period	Time-lagged period	Behaviour to lagged weight				Weight to lagged behaviour			
				CLs of *r*				CLs of *r*		
			r	low	high	*b*	*r*	low	High	*b*
1	R1-R3	R2-R3	-0.05	-0.44	0.36	-0.002	0.12	-0.30	0.50	0.95
2	R1-R2	R2-R3	-0.04	-0.44	0.37	-0.002	0.13	-0.29	0.51	-1.10

8.4 Discussion

8.4.1 Weekly monitoring of weight and occasion timings

The experiment in this Chapter clearly showed the feasibility of close tracking of the frequency of an eating or exercise pattern (a requirement specified in Chapter 2, section 2.5). Students rewarded with research participation credits succeeded in reporting weekly a recently read weight and timings for the most recent two occasions of consensually described patterns of eating or exercise. The issue remains that incentivised participation might have interfered with the ecological validity of changes in behaviour observed in this experiment and their persistence investigated in Chapter 10. That is, tracking of recordings of weight alongside occasions of habits and self-experimentation is only extended as compensation is provided for participation. Ideally, for mimicking normal life, such enrolment in the research needs to be motivated by participants' own interest in a healthy weight. Therefore, the subsequent tracking study among the same population of students (Chapter 9) faced the practical difficulty of obtaining continued weekly reports without relying entirely on participation credits.

Also, the number of reports made after a request was limited in this first experience of tracking by a delay in identifying individually feasible requests for healthy change in frequency. Nevertheless, the wait by participants left room for some series of reports of changes in frequency that had not been explicitly asked for. If some of these behaviour patterns change for any reason one at a time, their individual effect on weight can be tested without requests in a multiple baseline design.

Since most of the unasked changes were in a healthier direction, they were likely to have been intentional, whether or not also with a view to losing weight. Thus, these unasked-for changes provided opportunities for causal analyses (2.6.1) of associated changes in weight and frequency for a pattern of exercise and some patterns of eating, in addition to analysis of requested changes.

As anticipated (2.6.2), the amount of change in weight associated with a change in frequency seemed to vary among the patterns of behaviour. These difference in weight-reducing effectiveness might relate to the physiological mechanisms involved (1.7). Such effectiveness was tested in the subsequent experiment (Chapter 9) by comparing weight loss from requested change in experimental and control patterns, with hypothesised large and small effects on the target mechanism.

8.4.2 Exercise

One of the unrequested changes in monitored behaviour was an increase in what was described as *doing 30 minutes or more of vigorous exercise*. Although not reliably, the predicted slimming effect of increased exercise (2.7.10) was numerically noted.

Increase in *vigorous exercise* change was sometimes concurrent with increase in *cycling for 15 minutes or more*. Use of a bicycle may or may not be regarded as exercising "vigorously." Also "over 15 minutes" can overlap with "at least 30 minutes." Thus, it is important to generate mutually exclusive consensual descriptions of forms of physical activity (and of sedentary behaviour), so long as the number of patterns to be tracked can be kept manageable.

The increment from three to four occasions of vigorous exercise a week indicated the extent of change feasible in this locality. However, the overall incidence of exercising vigorously fell below the NHS in UK currently recommends 150 minutes of weekly physical activity for a healthy weight (http://www.nhs.uk/livewell/loseweight, accessed on 28/11/2012). Indeed, at least half of the participants exercised vigorously fewer than three times a week and about thirty percent did not engage in the exercise at all. Exercise of high intensity could be in addition a change difficult to maintain (1.7.2.5; 1.8.2.5). Thus, research is still needed for identifying other local patterns of physical activity for reducing weight.

8.4.3 Low-fat meals

Fewer occasions of a *meal low in fat* was the commonest unrequested change in frequency. In line with the proposed mechanism (1.7.1.1), weight loss was associated with sustained increase in low-fat meals of two weeks. Changes in frequency of a *meal low in fat* were sometimes concurrent with frequency changes in the pattern *vegetables or salad in a meal*. However, no evidence was found that increase in the frequency of vegetables reduced weight.

The concurrent changes in frequency between low-fat meals and vegetables or salad in meals may represent a conceptual interrelation between practices of healthy eating, as noted in Chapters 3 and 4. That a *meal low in fat* was higher in frequency than a veg./salad-containing meal indicated that some meals low in fat involve other types of food. However, the patterns of *meat with little/no fat* and *fruit at a meal* did not change with *meal low in fat* or *vegetables or salad in a meal* in the tested periods. It is possible that the students included other foods than these in what they regarded as low-fat meals.

This illustrates reasons for developing the method to collect data on the foods (Chapter 3) included in an agreed description of an eating pattern (Chapter 4), and similarly on the movements, loads and durations contributing to the intensity of exercise. This could also be worth collecting opinions of participants about which examples of foods or other concepts best describe an eating practice.

8.4.4 Calories between meals

The pattern with the highest median frequency among the students in this study was *having some snackfoods and/or a calorific drink between meals, e.g. a chocolate bar, biscuits, crisps, fruit juice or a sugar cola*. A decrease in calories between meals was also one of the commonest unrequested changes during the monitoring. Hence an intervention based on between-meal calories might be well complied with and could provide evidence having considerable ecological validity. Therefore, the request given highest priority in the next experiment (Chapter 9) was to reduce the frequency of calories between meals.

The persistent decrease in frequency of between-meal calories was associated over two weeks with reduced weight. This was in line with the mechanism (1.7.1.2) that snackfoods and calorific drinks between meals are fattening because their intake is poorly compensated. Cutting down on such extra energy reduces the rate of intake causing weight loss. A decrease in frequency of having the same sort of snackfoods and calorific drinks within meals should have a

smaller effect on weight because their compensation is better than between meals (2.7.2). To test this hypothesis experimentally in Chapter 9, snackfoods and/or calorific drinks between and within meals were compared in effect on weight, using a multiple-baseline design.

8.4.5 Changes before requested

The occurrence of unasked changes over the period of monitoring, in particular during the initial weeks, raises the possibility that some participants were acting from pre-existing motivation to live healthily or to control weight.

It is not known to what extent volunteering to take part in the study encouraged changes in eating or exercise. Some changes could have arisen in first-year students from adapting to life at university. Also, since about third percent of psychology students took part, talk between participants could have increased awareness about healthy eating and control of weight.

Unasked-for changes would be more likely when participants are not urged to maintain their eating and exercise as usual until requested to change. Even after requesting a change, it is essential to minimise the chance of changes in other habits because they could affect weight and thereby confound the multiple-baseline design and causal analysis (2.7). Thus, participants in experimentation on factors in weight control need to be briefed on the logical necessity of keeping all their habitual eating and exercise steady except for the habit(s) being investigated.

Also, to minimise changes in eating and exercise driven by health motivation, self-experimental change can be requested after one week of baseline monitoring, taken with data from the sample questionnaire at recruitment (Chapter 9 and 11). The early request, coupled with asymptotic weight change within 2-3 weeks, would have the further advantage of making less demand on students' research participation credits.

8.4.6 Causal analysis of correlated changes

There were too few participants for reliable tests of hypotheses about causal relationships between behaviour and weight. Nevertheless, the feasibility of cross-lagged correlational analysis and behaviour-weight dose-response estimates was illustrated for both unrequested and requested changes in frequency of eating and exercise patterns.

These results demonstrate the research value of frequent monitoring of behaviour and weight. Some participants did not comply with or lapsed from the asked change in frequency of a pattern [or changed direction after a change that was not asked for]. The timing of such events

and hence their effects on weight would have been unknown without weekly tracking. Indeed, more frequent reports would have been useful early in weight loss.

The results also illustrated how causal inferences drawn from means of frequency and weight can be unsound. This is a serious flaw in previous research (Chapter 1, sections 1.2 and 1.5). Correlational analysis (cross-lagged regression and factor analysis) showed that the means could be confounded by effects of weight change on behaviour, or a third factor such as an effort to eat more healthily and/or to exercise more.

CHAPTER 9
EFFECT ON WEIGHT OF A REQUESTED CHANGE IN FREQUENCY OF A PATTERN OF EATING OR EXERCISE

9.1 Introduction

9.1.1 Aim

The main purpose of this Chapter is to present group experiments on the effects on weight of individually decided changes in how often to carry out a specified pattern of eating or exercise. No control condition or group is needed, because the basic logic of causation can be deployed with a single group in a single condition (Chapter 2, section 2.6). Nevertheless, mechanisms of weight loss were tested by requesting changes in pairs designed as experimental and control conditions.

9.1.2 Approach

When volunteering, each participant agreed to change the frequency of up to two habits in turn when asked, during weekly tracking of weight read from scales and recalled timings of occasions of 19 types of eating and exercise in the way established in Chapter 8. One pattern was introduced at a time, to be changed in frequency to an extent chosen by the participant.

Each pair of experimental and control patterns of eating or exercise tested a mechanism by which a change in frequency was hypothesised to affect weight (Chapter 1, section 1.7, and Chapter 2, section 2.7). A pair of patterns was assigned to a participant only if that person's frequencies were not already so healthy compared with other participants that it was likely to be difficult to change further. In case some participants were willing to go on to change four patterns, each was initially assigned a sequence of two mechanism-testing pairs of experimental and control patterns. Four sequences balanced the alternations between and within the two pairs. Higher priority tests were assigned first to eligible participants in four sets of four sequences (eight mechanisms). This balanced sequence was cycled among participants as they volunteered and were found to be eligible in existing frequencies of the patterns.

The hypothesised mechanisms of weight change given highest priority for testing were energetic efficiency of bodily deposition of fat from the diet and less satiating energy between meals. This was on the basis of the evidence of their usefulness for reducing weight (Chapter 1,

sections 1.7.1.1 and 1.7.2.2). Also these mechanisms were investigated in the study presented in Chapter 8 where sample sizes were insufficient. As it turned out, these were the only tests of substantial numbers of participants in the study in this chapter.

The test of fat's energetic efficiency in weight gain was to decrease the proportion of dietary fat in regular meals by increasing carbohydrate and protein contents within the same total energy. That is, the experiment requires fat-rich meals to be replaced by meals of equal energy content based on carbohydrate-rich foods cooked without fat, such as pasta and potato; just cutting fat reduces overall calories. Thus, participants were asked to reduce the frequency of meals high in fat in the experimental condition and high in carbohydrate in the control condition, which in practice means low in fat and low in protein as well. Even if the high-fat and high-carbohydrate meals contained the same amount of energy (calories), in theory more of the energy in the carbohydrate would be spent synthesising fat for deposition when the rate of energy intake was greater than the rate of energy expenditure (1.7.1.1).

The test for an effect on weight of ingesting energy between meals was a decrease in frequency of the consumption of items perceived as *snackfoods* (usually energy-dense packet foods) and energy-containing drinks between meals in the experimental condition and of the same sorts of food and energy-containing drinks but just within meals as the control condition. In theory, the timing of consumption between meals produces less effective 'compensation' by decrease in subsequent intake, especially at the next meal (1.7.1.2).

9.1.3 Expected findings

The general hypothesis was that a persisting change in frequency of an experimental pattern would cause a larger reduction in weight to asymptote than such a change in the control pattern. If successive changes in frequency were requested after weight had reached asymptote each time, stepwise reduction in weight was expected.

9.2 Method

9.2.1 Participants

Participants were 45 students of the School of Psychology of the University of Birmingham. They were all British-domiciled students, 43 women and two men, with a mean age of 20 years (*SD* = 1 y). The declared ethnic backgrounds were 34 white British, seven Asian, two black African, one white European and one Jewish.

9.2.2 Design

The study reported in this Chapter had a within-subjects multiple-baseline design (2.7). Each volunteer in a cohort took part for several weeks in a weekly online session of about 20 minutes. In addition, there were within subject contrasts between experimental and control habits.

9.2.3 Procedure

9.2.3.1 Recruitment with informed consent

The experiment was conducted on the research website (RPS, Sona Systems Ltd) used in the School of Psychology to advertise experiments and mount online questionnaires. The study was posted with the title *Experiment on yourself*. In the recruiting session, the student completed one of this study's weekly questionnaires, learnt about interest in generating evidence on what customs affect weight the most and was invited to collaborate in such research after consenting to the following procedures.

Participants would fill in the same questionnaire once a week while in Birmingham for as much of the academic year as possible. They would need bathroom scales to weigh themselves on the day of each report. At intervals they would be asked to carry out one of the reported patterns of eating or exercise less or more often to an extent that they could maintain. At least two patterns needed changing in order to contribute to a controlled experiment.

Reports would be recorded anonymously using an ID number. At the end of each set of five reports, research participation credit would be transferred to the participant's ID via the RPS. Only an email address was needed by the researcher, for sending a reminder when the weekly report was due and the requests to change how often an assigned type of eating or exercise was carried out.

At the end of the above information, the student was asked if s/he would like to part in the experiment with the options to respond, "Yes, I would," "No, I wouldn't" or "Maybe"

A total of 195 psychology students completed the sample questionnaire (Report 0) during Autumn Term 2009. The invitation to take part in the experiment was extended to students and staff from around the campus through an announcement posted on the University internet portal during the Spring Term 2010. In response, another 116 people filled in the sample questionnaire. Of these 311 people, 111 (36%) agreed to take part, 59 (19%) responded that they may be interested and 139 (45%) answered that they would not take part. Very few people who answered

'Maybe' joined the study after an approach by email. The number who provided a subsequent report was 79 (71% of 111).

A set of five reports was provided by 45 people (57% of those who completed one report). A second set was completed by 13 people (9%), 5 (6%) did 15 reports and 3 (4%) 20 reports. Despite the large response from people across the campus, the ID numbers indicated that participants who continued providing weekly reports were all students in Psychology.

9.2.3.2 Monitoring of weight and behaviour

Volunteers were asked to select a day of the week that they could maintain throughout Term-time for making the report each week. Participants were reminded by email on the day before their next report was due. That message provided the link to this study on the RPS, the number of that report and a reminder to measure weight before answering the questionnaire.

The instructions for measuring weight were to take the reading each week on the same scales at the same time of day, preferably after getting up and before any meal, having relieved oneself and wearing at most light clothing with no shoes.

9.2.4 Questionnaire instrument

The questionnaire consisted of 40 items. The first two items asked for the weight either in kilograms including fractions or in stones and pounds (or just pounds) and the time that the weight was read off the scales. Then, a pair of questions was asked for each of 19 described patterns of ingestion or movement that could be used for experimental requests to change frequency (Table 9.1).

The first question in a pair asked for the timing of the most recent occasion when the participant carried out the pattern: "When did you last [*pattern wording*]?" The second question asked for the timing of the occasion before the last: "When was the occasion before that?" To improve the recall of timings, participants were advised to remember first *where* they were and *who* else was there. Participants entered in a blank response space below the question the *time* and *date* of each recalled occasions in the format Hour:Min am/pm Day Month Year, with hour, minute, day of the month and (abbreviated) year in numerals and am/pm and month in letters.

So that participants focused on remembering the occasions of one pattern at a time, the patterns were presented in separate sections. Nevertheless, participants could revise their responses in they wished at the end of the questionnaire.

Table 9.1 Physiological mechanisms tested by use of descriptions of experimental (E) and control (C) patterns of eating or exercise.

Mechanism Code for condition / group	Wording for the pattern of eating or exercise used in the condition
Energetic efficiency of dietary fat	
E – HiFat	Have a meal based on fat-rich food - for example, cheese, sausages, streaky bacon, fried bread, lots of fatty spread or oil.
C – HiCHO	Have a meal that was low in fat and had very little protein for example, pasta topped with tomato sauce, a salad, baked potato, bread and Marmite or jam, a dish based on vegetables only, toast with marmalade only.
Less satiating energy between meals	
E – EnBM	Have a drink with calories in it between meals - for example, apple juice, Coca cola, beer, vodka, coffee with cream and/or sugar. Have one or more snackfoods between meals - for example, crisps, sweets, chocolate bar, cake, biscuits.
C – EnWM	Have a drink with calories in it as part of a meal or shortly before the meal Have one or more snackfoods as part of a full meal or slightly before a meal
Eating at mealtimes	
E – Breakfast	Eat something at breakfasttime - for example, cereal or toast.
E – Lunch	Eat something at lunchtime
E – Dinner	Eat just once between late afternoon and bedtime
E – Eat twice in evening	Eat twice or more between the late afternoon and going to bed It might have been tea and supper, or dinner and a nightcap.
Satiating effect of protein	
E – HiPro	Have non-fatty high-protein food in a meal - for example, egg, low-fat cheese, skinless chicken, fish (not deep-fried), prawns, meat without any fat you could see.
C – HiCHO (above)	
Conditioning of satiety	
E – BreadSM	Eat bread at the start of a meal which was several hours after the previous meal
C – BreadAMS	Eat bread in a meal after other foods
Energy expenditure	
E – Walk	Walk fast from one place to another
E – Move around	Spend some time moving around when you might have been sitting down
E – Stairs	Walk both up and down stairs when a lift or escalator was available
E – Housework	Do some housework – for example, hoover the house, clean the bathroom
E – Something energetic	Do something really energetic e.g., jog, gym, fitness class, swim, sport.
Pattern not affecting energy intake	
C – Salt[a]	Add salt to your food or choose some salty product such as salted crisps, peanuts or 'lassi' drink

[a]The pattern Salt is used as the control condition for mechanisms tested only with experimental patterns.

The patterns were presented in the sequence in which they are likely to be carried out during the day. This usual order of occurrence might help to prompt the recall of activities, in addition to a recommendation at the start to think of location and company. This sequencing of the patterns was informed by the orders of everyday activities reported by students in the experiment on forward and backward recall in Chapter 5.

The first pattern on the questionnaire was eating at breakfast time which by definition is the first ingestive activity of the day. However, students' reports of breakfast indicated that these episodes generally did not involve major cooking or other preparation. Therefore questions about sorts of meals were left for episodes later in the day.

Walking was reported at many times of day but walking to the campus in the morning was common. Hence the second pattern was *Walk fast*. The use of stairs was likely for students on their way to the campus (as well as later in the day) and so *using stairs rather than lift* was the second pattern. This also meant that exercise appeared early in the questionnaire, as well as eating.

Students had reported drinking coffee or a soft drink during the morning, sometimes on campus. So questions about energy-containing drinks were asked next. The questions about snackfoods, however, were asked later, to correspond with the long interval between lunch and supper. Although some reports of breakfast included toast, a good number of reports of lunch included bread. Hence the question about bread at the start of a meal was asked next. Eating at lunch time was placed after that, followed by the question about bread after a meal. Some recalled lunch occasions involved fried or fatty foods and so the high-fat meal came next in the questioning.

To continue exploiting successive recall over the rest of the day but also to break up the succession of eating episodes, the questions about housework and moving around were asked next. Cleaning activities were reported in the afternoon or evening. Sedentary behaviours such as computer use, watching TV or other seated leisure activities were recalled as more frequent as the day progressed.

The patterns involving snackfoods, eating twice in the late afternoon/evening and once at evening were placed next, in that order. In Chapter 5, eating in the afternoon was recalled to be more variable than in the morning, presumably because of the longer interval between lunch and an evening meal. Students recalled evening meals in detail, possibly because they usually cooked

dinner. Diverse courses were mentioned more frequently in the evening. Hence the next questions were those about the patterns of high-protein and high-carbohydrate meals and using salt.

Sport was most likely in the afternoon or evening on a weekday, although the prevalence of highly energetic activities was rather low. Hence this question was placed last in the order.

9.2.5 Experimental intervention

9.2.5.1 The participant's eligibility for change in the frequency of a pattern

A participant was regarded as eligible to be asked to change the frequency of a pattern in the healthier direction if the evidence indicated that such a change was sufficiently feasible. The criterion was that the participant's current frequency of that pattern was not beyond the healthier quartile in the grouped data thus far available. If this criterion was not met in the first weekly report, the second report was examined and, if necessary, the third.

Participants were also screened for risk of an experimental weight loss taking them below the healthy range of body mass index (BMI: weight in kilograms divided by height in metres squared), namely 18.5 to 25 in adults. The group investigated in this Chapter had a mean BMI of 23 $kg.m^{-2}$, with a standard deviation of 3. The findings in the previous Chapter indicated a maximum weight loss from a sustained change in frequency of the patterns investigated in that study of between about 0.5 and 1.0 kg (sections 8.3.6 and 8.3.8.1). Hence participants with a BMI above 20 were considered to be eligible by this criterion as they had a range of at least 1.5 kg to lose before the lower limit of BMI.

Finally, both the recorded weight and the frequency of the pattern for requested change in frequency had to be at a steady level, for the averages to serve as baselines. This criterion was met if the same values appeared in the responses to the recruiting questionnaire and in the first report. It was also met if there had not been two changes in the same direction by the second report: even if changes in opposite directions did not average at zero, they indicated variation around a constant level rather than the possible start of a trend. Two changes in the same direction could be countered by a substantial change in the opposite direction in the third report.

9.2.5.2 Request to change frequency

Eligible participants were emailed a request within a day after the return of their latest report (Table 9.2). To communicate the requested direction of change, the wording of the pattern

to be changed (Table 9.1) was edited to include the clause either “do more often” or “do less often” The request also pointed out the benefit to health from the change.

Participants were invited to make the change to an extent that they could maintain until at least the end of the Term. Also, participants were asked to do their other eating and exercise as often or seldom as usual. This instruction was intended to minimise the risk of other behaviour changing in frequency in correlation with requested pattern.

Participants were given the option of asking for another change if they did not want to make the assigned change. When a participant asked for another change, the experimental or control pattern of the next mechanism in the designed sequence was used for the request.

A high rate of drops out interfered with the expected full-scale experimentation. Nevertheless, the prioritised mechanisms ‘energetic efficiency of dietary fat’ and ‘less satiating energy between meals’ were carried out as planned among participants who continued their participation and who received requests to change the frequency of a pair of patterns (Table 9.2). Participants returned on average four reports after each request. The mean time between one request and the next ranged from 23 to 38 days.

9.2.6 Analysis of data

The treatment of data to measure the effect on weight of changes in the frequency of a pattern of behaviour is fully described in Chapter 8 (8.2.7) for the first tracking study. However, this Chapter had a particular focus on maintained changes in behaviour.

Change in frequency of a habit. The number of times per week that the habit is currently carried out was estimated as the reciprocal of seven days divided by the fractional number of weeks between the two recalled timings of the most recent occasions. Change in frequency of a habit was measured from a baseline of frequencies averaged over two weeks of reports. This was the minimum period for a reliable reduction in the variance of mean frequency of a habit in these data.

To correlate with weight loss, the change in frequency was taken to be the mean of the weekly frequencies from baseline until returned to 75% of the baseline.

Table 9.2 Sequences (1st to 4th) of requests to change frequency of an eating or exercise pattern. The codes for described patterns of behaviour are defined in Table 9.1.

Mechanism tested Experimental (E) and Control (C) patterns	1st	2nd	3rd	4th
Energetic efficiency of dietary fat				
E – LessHiFat	5	1	1	-
C - LessHiCHO[a]	5	1	-	2
Less satiating energy between meals				
E –LessEnBM	9	3	2	-
C –LessEnWM	10	1	-	1
T – Eat twice in evening	-	-	-	-
Satiating effect of protein				
E – HiPro	2	-	-	-
C- LessHiCHO[a]				
Conditioning of satiety				
E – BreadSM	-	-	-	-
C – BreadAMS				
Energy expenditure				
E – Walk	-	-	-	-
E – Move around	1	-	-	-
E – Stairs	-	-	-	-
E – Housework	-	-	-	-
E – Something Energetic	1	-	-	-
Eating episodes at mealtimes				
E – Breakfast	-	-	-	-
E – Lunch	-	-	-	-
E – Dinner	-	-	-	-
Pattern not affecting energy intake				
C – Salt	1	-	-	-
Total number of Requests made	35	6	3	3
Mean no. of Reports returned after Request	4	4	5	4
Mean days before next request or last Report	26	38	31	23

[a] The same pattern served as the Control condition for two mechanisms.

Step change in weight. Any change in weight of an individual during a sustained change in frequency was considered to have reached asymptote if it had not returned to baseline by the end of the analysed period. The mean weight during that period was used as the variable in regression.

Effect of change in frequency on weight. For each habit, those individuals showing a sustained changed in frequency for a particular number of weeks, and any weight change had also been sustained, were included in the estimation of the effect on weight of a change of frequency of that habit. Any individual was excluded who showed a change in frequency or weight more than 2.5 standard deviations from the mean of the remaining group ($p < 0.05$).

The slope (b) of the least-squares regression from frequency change to weight change gives a group-based estimate of the amount of weight lost for a frequency reduction of once a week. The validity of these estimates was shown by a reliable difference in regression coefficients between two habits that theoretically differ in impact on weight. Using the r-to-z transformation, the difference between the two values of z gave the p value of no difference between the two regression coefficients.

Direction of causation. To test if the direction of the causation was from behaviour to weight and/or weight to behaviour, the differences in frequency were regressed with the difference in frequency over the same period but started a week later and the weight difference with the frequency change starting one week later. The difference between the regression coefficients was tested using the r to z transformation.

9.3 Results

9.3.1 Weeks needed for baseline values

For both behaviour frequencies and weight, the expected decrease in mean variance with number of variances averaged was seen in the first five weeks of reports, whether the periods were increased from Week 1 onwards or backwards in time from Week 5 (Tables 9.3 and 9.4). However, there were twice as many reductions in average variance from a single week to two weeks when going from Week 1 to the average of Weeks 1 and 2 (Table 9.3) than when comparing Week 5 with Weeks 5 and 4 (Table 9.4). That numerical contrast is consistent with the hypothesis that individuals' frequencies were changing more at the start of monitoring than later.

Table 9.3 Variances in frequency averaged over increasing numbers of weekly observations from Week 1 to Week 5, with integer-rounded ratios of variance (dividing shorter by longer periods). Wk = week number of the datum. wk = weeks unit of duration.

Pattern	*k*	Group variance in mean frequency					Ratio of variances for durations			
		Week 1	Wks 1 to 2 mean	Wks 1 to 3 mean	Wks 1 to 4 mean	Wks 1 to 5 mean	1 wk / 2 wk	2 wk / 3 wk	3 wk / 4 wk	4 wk / 5 wk
LessHiFat	44	41	22	34	28	23	2*	1	1	1
HiPro	45	257	75	38	32	22	3**	2**	1	1
LessHiCHO	44	25E4	65E3	29E3	16E3	10E3	4**	2**	2*	2[m]
DrinkBM	44	111	745	1811	1597	1522	0	0	1	1
DrinkWM	45	204	75	51	35	32	3**	1[m]	1[m]	1
SnackBM	45	629	309	2671	1954	1351	2**	0	1	1[m]
SnackWM	44	23	308	239	811	1030	0	1	0	1
Salt	43	125	705	334	231	166	0	2**	1	1
Walk	45	3975	4349	2582	2243	2101	1	2	1	1
Move	45	752	532	388	474	488	1	1	1	1
Stairs	45	5511	2237	5057	6343	4546	2**	0	1	1
Housework	45	16	626	278	169	109	0	2*	2*	2[m]
DoSmthEn	44	12	5	11	9	226	2**	0	1	0
Breakfast	44	3	4	72	43	29	1	0	2*	1
EatTwice	44	96	98	164	169	159	1	1	1	1
Dinner	44	54	68	34	22	68	1	2**	2[m]	0
Lunch	44	137	38	290	166	107	4**	0	2*	2[m]
BreadSM	45	42	21	23	22	16	2**	1	1	1
BreadAMS	45	50	26	37	27	20	2*	1	1	1
Weight	44	151	153	153	154	154	1	1	1	1

Increase in variance at $^{**}p < 0.01$, $^{*}p < 0.05$, $^{m}p < 0.1$.

Table 9.4 Variances in frequency averaged over increasing numbers of weekly observations from Week 5 alone to Weeks 5 to 1, with the integer-rounded ratios of variance (dividing shorter by longer periods). Wk = week number of the datum. wk = weeks unit of duration.

Pattern	*k*	Group variance in mean frequency					Ratio of variances for durations			
		Week 5	Wks 4 & 5 mean	Wks 3 to 5 mean	Wks 2 to 5 mean	Wks 1 to 5 mean	1 wk / 2 wk	2 wk / 3 wk	3 wk / 4 wk	4 wk / 5 wk
LessHiFat	44	33	33	47	31	23	1	1	2^{m}	1
HiPro	45	76	48	46	29	22	2^{m}	1	2^{m}	1
LessHiCHO	44	64	22	17	19	10551	3**	1	1	0
DrinkBM	44	1408	1331	2595	2329	1522	1	1	1	2^{m}
DrinkWM	45	120	41	42	31	32	3**	1	1	1
SnackBM	45	918	573	3321	1895	1351	2^{m}	0	2*	1
SnackWM	44	3294	6281	2811	1625	1030	1	2**	2*	2^{m}
Salt	43	101	200	106	232	166	1	2*	0	1
Walk	45	2042	2146	1621	2499	2101	1	1	1	1
Move	45	1771	1090	644	591	488	2^{m}	2*	1	1
Stairs	45	3967	4743	9494	5900	4546	1	0	2^{m}	1
Housework	45	13	51	27	167	109	0	2*	0	2^{m}
DoSmthEn	44	5717	1424	631	354	226	4**	2**	2*	2^{m}
Breakfast	44	9	5	74	44	29	2*	0	2*	2^{m}
EatTwice	44	9	5	74	44	29	2*	0	2*	2
Dinner	44	859	227	106	76	68	4**	2**	1	1
Lunch	44	6	4	280	160	107	1	0	2*	1^{m}
BreadSM	45	11	21	29	20	16	1	1	1^{m}	1
BreadAMS	45	29	16	39	26	20	2*	0	2^{m}	1
Weight	44	151	156	156	155	154	1	1	2^{m}	1

Reliability of increase in variance with duration: $^{**}p < 0.01$, $^{*}p < 0.05$, $^{m}p < 0.1$.

Hence the baseline for an individual could be more reliable if the first two weeks were considered, rather than only Week 1.

This indication of an initial reduction in individuals' variation persisted into Week 3 or even Week 4 in the case solely of frequency of high-carbohydrate meals. However, these frequencies were extremely high in Week 1 (higher even than walking and using stairs). The very sharp reduction in variance from Week 2 may reflect a difficulty for some participants in the categorisation of such meals, which could have persisted to some extent in subsequent weeks. It may be therefore be unwise to draw strong conclusions about this pattern, especially if the inferences depend on frequencies in the first week or two of monitoring.

9.3.2 Initial changes in frequency of patterns

There was some evidence of individuals altering the frequencies of a few patterns of eating or exercise immediately after entering the study, before a request to change had been made (Table 9.5). However, any such shifts were not consistently in what is generally regarded as a healthy direction, as might be expected from self-presentation biases.

Reliably more participants increased frequency of breakfast than decreased it from the recruitment session to the first weekly monitoring (Table 9.5, pattern 1). Taking as random at this stage of monitoring the smaller number of changes replicated in Weeks 1 and 2 (21), about 30% of these participants had breakfast more often in Week 1 than at recruitment, although about half of these 'relapsed' in Week 2.

There may also have been a systematic increase in frequency of high-protein meals from recruitment to the first report, again with numerical signs of a substantial proportion of relapses in subsequent weeks (Table 9.5, pattern 17). However, this Table has 95 comparisons and so $p < 0.01$ could occur once by chance. Nevertheless, this occurrence was at the start of monitoring and so has more chance theoretically of being an actual effect. There was one other $p < 0.01$ from Weeks 3 to 5, a potentially healthy decrease in frequency of consumption of *snackfoods* between meals (Table 9.5, pattern 10); in some cases at least, this decrease was in response to a request. Five group directional changes in frequency reached $p < 0.05$, four of them within the first two weeks of monitoring; two were in eating and two in exercise (with one in an unhealthy direction).

Table 9.5 Counts of directional frequency change in each pattern over successive weeks the first set of weekly reports (Rn).

Pattern	R0 to R1				R1 to R2				R1 to R3				R2 to R4				R3 to R5			
	k	*up*	*dn*		*k*	*up*	*dn*		*k*	*up*	*dn*		*k*	*up*	*dn*		*k*	*up*	*dn*	
1. Breakfast	79	46	21	***	64	21	35	^{m}	54	0	2		47	2	0		44	1	0	
2. Walk	78	38	37		63	33	29	***	53	3	7	***	48	0	2		45	1	5	^{m}
3. Stairs	79	46	27	*	63	27	30		53	2	2		48	1	1	***	45	3	3	***
4. DrinkBM	79	34	33		64	22	37	*	54	1	4		48	3	3		44	2	4	
5. DrinkWM	79	31	37		64	25	31		54	1	3		48	2	4		45	0	2	
6. BreadSM	79	35	24		64	24	25		54	5	4		48	0	0		45	1	1	
7. Lunch	79	34	28		64	23	30		54	0	0		48	0	0		44	0	0	
8. BreadAMS	79	37	28		64	22	29		54	1	3		48	0	2		45	1	3	
8. LessHiFat	78	40	36		64	31	30		54	2	1		48	1	3		44	1	5	^{m}
10. SnackBM	79	29	41		64	32	23		54	2	1		48	0	1		45	0	6	**
11. SnackWM	78	34	32		63	24	27		53	1	2		47	2	3		45	0	2	
12. Housework	79	31	40		64	32	26		54	2	1		48	2	1		45	0	1	
13. Move	79	38	34		64	30	32		54	2	5		48	1	2		45	1	0	
14. EatTwice	79	40	30		64	26	29		54	1	3		48	1	1		44	1	3	
15. Dinner	78	36	30		64	27	31		53	2	3		47	1	3		44	0	1	
16. Salt	79	27	36		64	33	18	*	52	1	3		46	1	3		43	0	1	
17. HiPro	79	44	23	**	64	24	32		54	4	8		48	2	1		45	0	2	
18. LessHiCHO	79	36	34		64	23	30		54	1	2		47	0	4	*	44	1	3	
19. DoSmthgEn	79	38	33		63	18	35	*	53	1	1		47	0	3	^{m}	45	1	3	

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ^{m} $p < 0.1$ in χ^2

9.3.3 Correlation between changes in habit frequency and weight

9.3.3.1 Energetic efficiency of dietary fat

In agreement with the hypothesis, the persistent decrease in frequency of *fat-rich meals* was associated with weight loss over three and two weeks (Table 9.6, Figures 9.1 and 9.3). In contrast, decrease in frequency of *meals that are low in fat and have very little protein* was associated with gain weight at same time intervals (Table 9.6, Figures 9.2 and 9.4). Over the period of three weeks, the correlation coefficient of changes in frequency of fat-rich meals with change in weight differed reliably from the correlation coefficient of frequency change of meals that are low in fat and protein and change in weight (Table 9.6, Figures 9.1 and 9.2). The weight loss estimated was about 600 grams (Table 9.6, Figure 9.1) from decrease in frequency of once per week (opw) in fat-rich meals.

Table 9.6 Size of step change in weight produced by self-experimental change in frequency of either ***rich-fat meals*** (HiFat) or ***meals low in fat with very little protein*** (HiCHO).

						CLs of *b* g/opw		Differences	
Figure no	Behaviour	Period	*N*	*r*	*b* g/opw	low	high	*z* score	1-tail *p* <
9.1	HiFat	R0 to R3	5	0.88	606	-3	1215		
								1.9	0.03
9.2	HiCHO	R0 to R3	5	-0.46	-50	-228	129		
9.3	HiFat	R0 to R2	5	0.27	38	-212	288		
								0.5	0.31
9.4	HiCHO	R0 to R2	5	-0.21	-3	-34	27		

Figure 9.1 Change in weight estimated from change in frequency of ***rich-fat meals*** maintained over three weeks. The slope of the linear regression (line through the data) gives an estimated effect of 606 g of weight loss for a reduction in frequency of once per week (opw; Table 9.6).

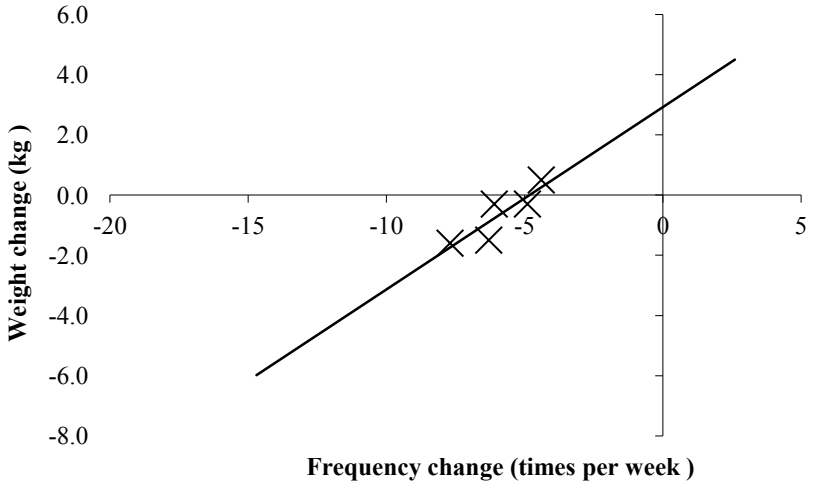


Figure 9.2 Change in weight estimated from change in frequency of ***meals low in fat with very little protein*** maintained over three weeks. The regression line from weight change to frequency change has a slope of - 50 g/opw (Table 9.6).

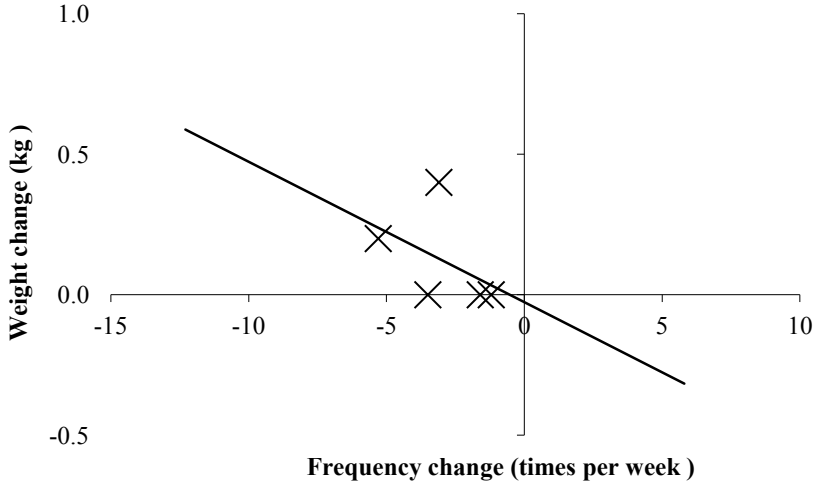


Figure 9.3 Change in weight estimated from change in frequency of ***rich-fat meals*** maintained over two weeks. Regression slope of 38 g/opw (Table 9.6).

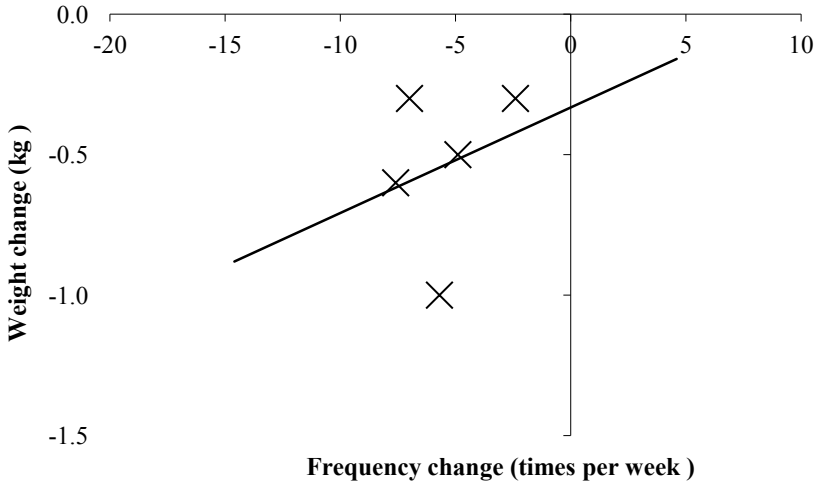
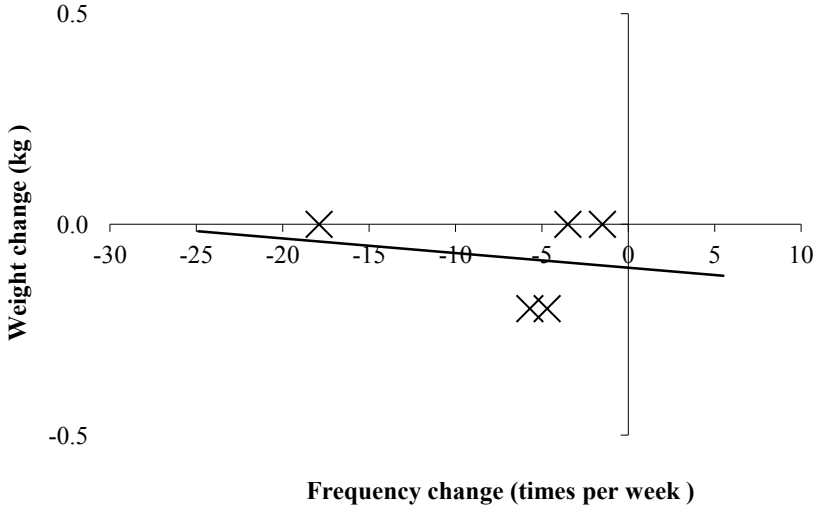


Figure 9.4 Change in weight estimated from change in frequency of ***meals low in fat with very little protein*** maintained over two weeks. Regression slope of -3 g/opw (Table 9.6).



Regressions over the three week period indicated a consistent positive association between frequency change in fat-rich meals and change in weight starting later (Table 9.7, Figures 9.5, 9.7, 9.9, 9.11 and 9.13). No difference in correlation was found between frequency change with lagged change in weight and weight change with lagged change in frequency (Table 9.7, Figures 9.5-9.14). Thus, considering that these changes in frequency were requested, it is likely that the causal direction was from behaviour to weight. The regressions of frequency change in fat-rich meals estimated a lagged effect on weight of 120 to 376 g per decrease of once per week.

Table 9.7 Time-lagged regressions of changes in weight and frequency of ***fat-rich meals*** over period of largest effect.

Figures no	Pre-dictor period	Time-lagged period	*N*	Behaviour to lagged weight				Weight to lagged behaviour				Differences	
						CLs of *b*				CLs of *b*			
				r	*b*	low	high	*r*	*b*	low	high	*z* score	1-tail *p* <
9.5 & 9.6	R0-R3	R1-R3	5	0.69	376	-354	1106	0.39	531	-1747	2808	0.43	0.33
9.7 & 9.8	R1-R2	R2-R3	5	0.27	120	-675	914	-0.54	-2713	-10416	4990	0.88	0.19
9.9 & 9.10	R1-R3	R2-R3	5	0.60	357	-514	1228	-0.19	-559	-5982	4863	0.89	0.18
9.11 & 9.12	R0-R2	R1-R2	5	0.44	154	-595	903	-0.13	-643	-9873	8587	0.60	0.27
9.13 & 9.14	R0-R1	R1-R2	5	0.49	188	-644	1020	-0.22	-1092	-7367	5184	0.76	0.22

Figure 9.5 Lagged change in weight estimated from change in frequency of ***fat-rich meals*** over period of largest effect. Regression slope of 376 g/opw (Table 9.7; Behaviour to lagged weight).

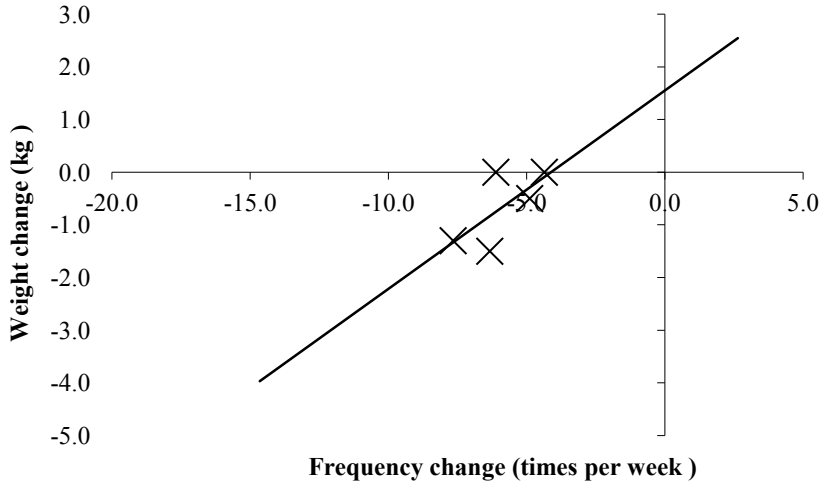


Figure 9.6 Cross-lagged change in frequency of ***fat-rich meals*** estimated from change in weight over period of largest effect. Regression slope of 531 tpw/kg (Table 9.7; Weight to lagged behaviour).

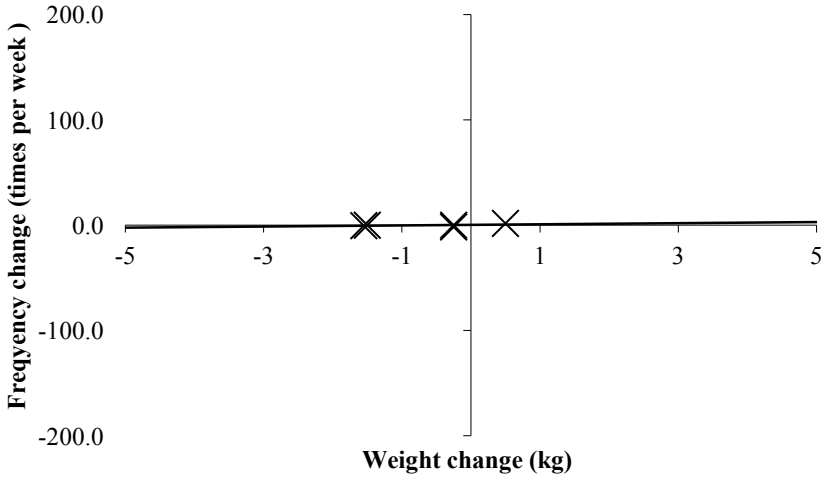


Figure 9.7 Lagged change in weight estimated from change in frequency of ***fat-rich meals*** over period of largest effect. Regression slope of 120 g/opw (Table 9.7; Behaviour to lagged weight).

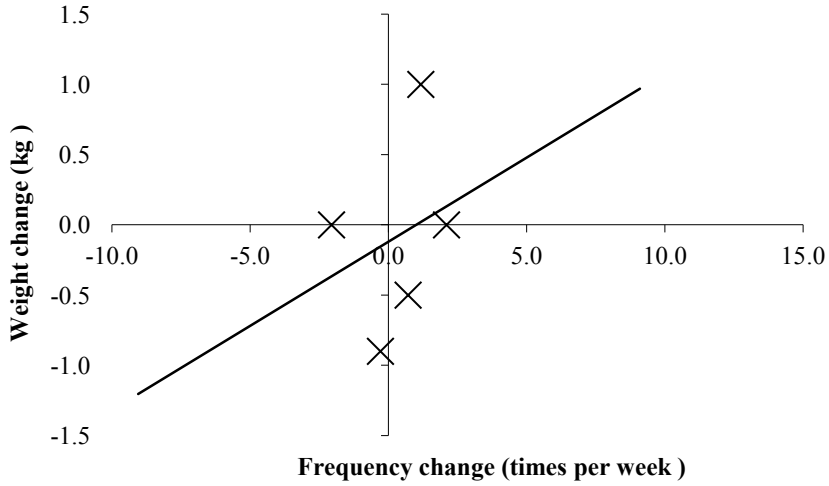


Figure 9.8 Cross-lagged change in frequency of ***fat-rich meals*** estimated from change in weight over period of largest effect. Regression slope of -2712 tpw/kg (Table 9.7; Weight to lagged behaviour).

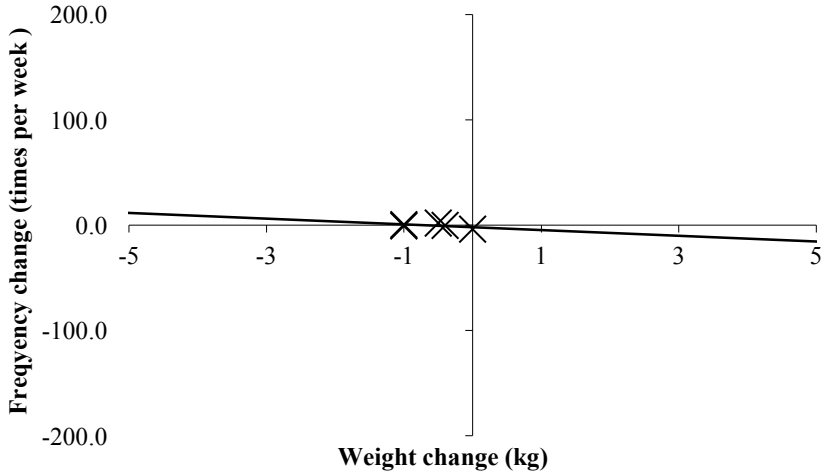


Figure 9.9 Lagged change in weight estimated from change in frequency of ***fat-rich meals*** over period of largest effect. Regression slope of 357 g/opw (Table 9.7; Behaviour to lagged weight).

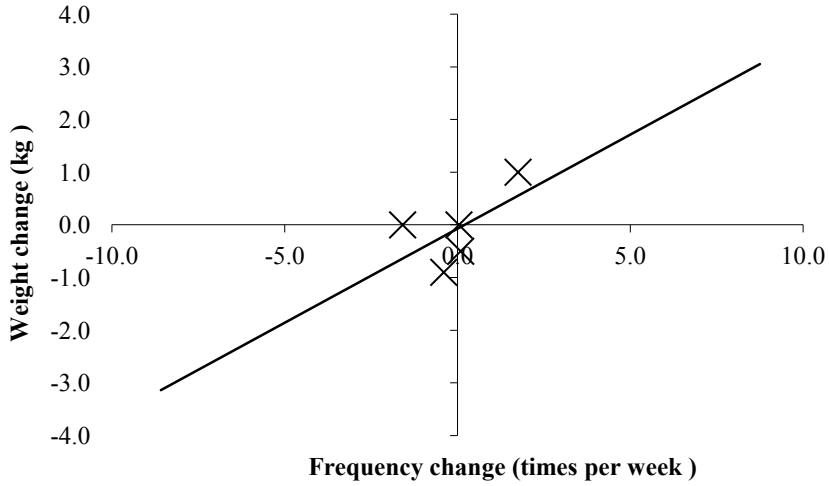


Figure 9.10 Cross-lagged change in frequency of ***fat-rich meals*** estimated from change in weight over period of largest effect. Regression slope of -559 tpw/kg (Table 9.7; Weight to lagged behaviour).

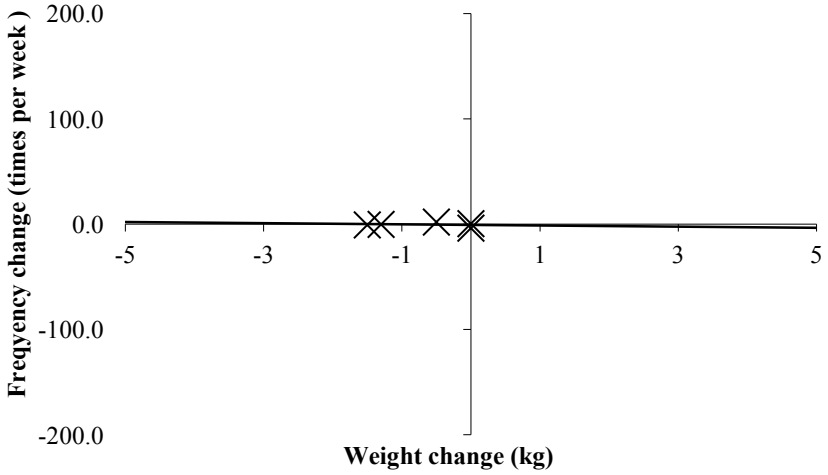


Figure 9.11 Lagged change in weight estimated from change in frequency of ***fat-rich meals*** over period of second largest effect. Regression slope of 154 g/opw (Table 9.7; Behaviour to lagged weight).

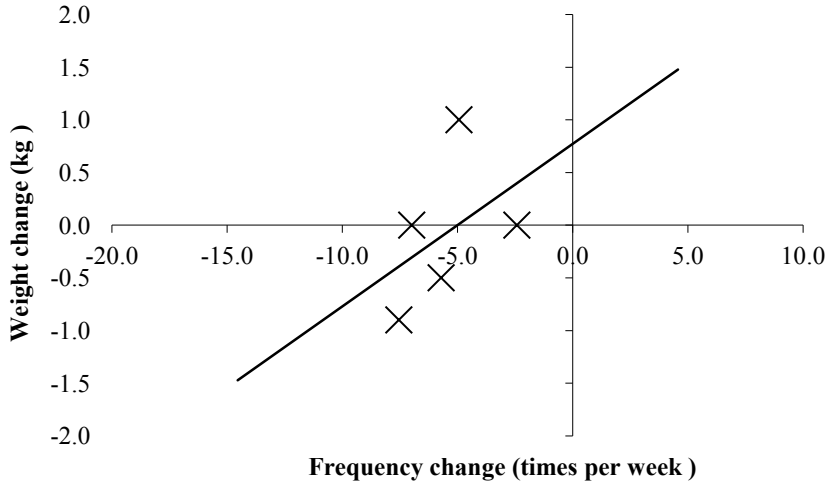


Figure 9.12 Cross-lagged change in frequency of ***fat-rich meals*** estimated from change in weight over period of second largest effect. Regression slope of -643 tpw/kg (Table 9.7; Weight to lagged behaviour).

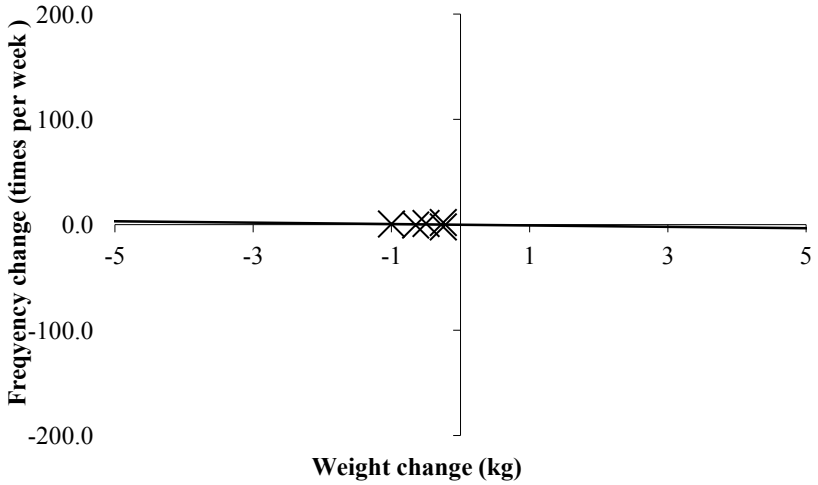


Figure 9.13 Lagged change in weight estimated from change in frequency of ***fat-rich meals*** over period of second largest effect. Regression slope of 188 g/opw (Table 9.7; Behaviour to lagged weight).

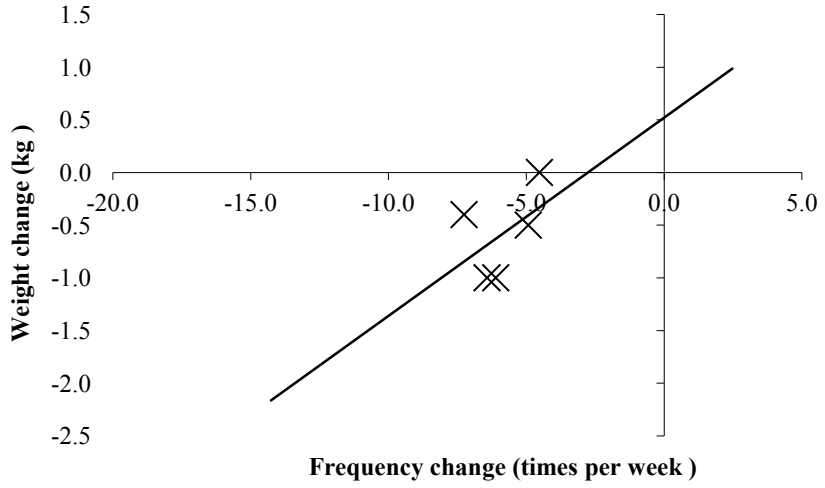
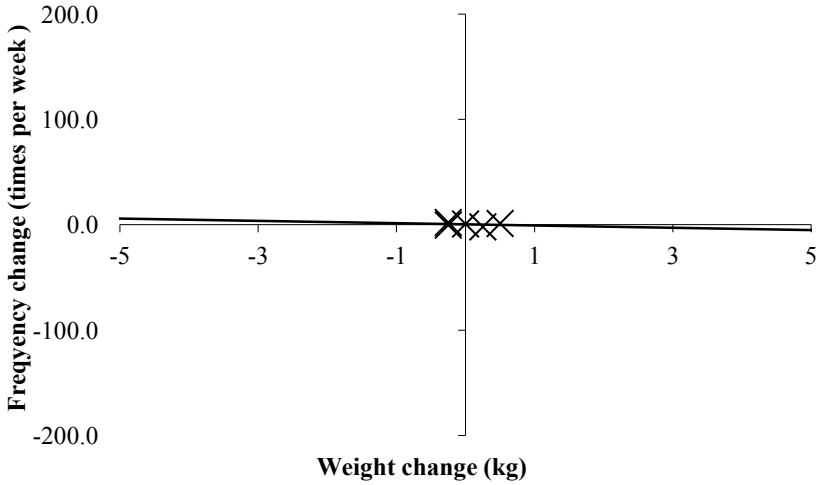


Figure 9.14 Cross-lagged change in frequency of ***fat-rich meals*** estimated from change in weight over period of second largest effect. Regression slope of -1092 tpw/kg (Table 9.7; Weight to lagged behaviour).



9.3.3.2 Calories not well compensated between meals.

The findings were consistent with the hypothesis that consumption of snackfoods and drinks is more fattening between meals than within meals (Table 9.8; Figures 9.15-9.18). A persisting decrease in frequency of snackfoods and calorific drinks between meals was associated with weight loss to a slight extent over a period of three weeks (Figure 9.15) and more substantially over two weeks (Figure 9.17). In contrast, the decrease in frequency of consuming the same foods and drinks within a meal was associated with weight gain over three and two weeks (Table 9.8, Figures 9.16 and 9.18). The difference between the correlation coefficients approached the conventional level of *p* for statistical significance over the 2-week period, despite the small numbers (Table 9.8, *z*- scores for Figures 9.17 and 9.18). The amount of weight lost for a reduction in frequency of one snack per week was estimated by these data to be the order of about 10 g (Table 9.8, Figure 9.17).

Table 9.8 Size of step change in weight produced by self-experimental change in frequency of ***snackfoods and calorific drinks*** either ***between meals*** (sfdBM) or ***within meals*** (sfdWM).

Figure no	Behaviour	Period	*N*	*r*	*b* g/opw	CLs of *b* g/opw low	CLs of *b* g/opw high	Differences *z* score	Differences 1-tail *p* <
9.15	sfdBM	R0 to R3	6	0.26	7	-27	40		
								1.1	0.14
9.16	sfdWM	R0 to R3	9	-0.46	-7	-20	5		
9.17	sfdBM	R0 to R2	5	0.62	11	-14	37		
								2.1	0.08
9.18	sfdWM	R0 to R2	8	-0.43	-7	-21	7		

Figure 9.15 Change in weight estimated from change in frequency of ***snackfoods and calorific drinks between meals*** maintained over three weeks. The slope of the linear regression (line through the data) gives an estimated effect of 7 g of weight loss for a reduction in frequency of once per week (opw; Table 9.8).

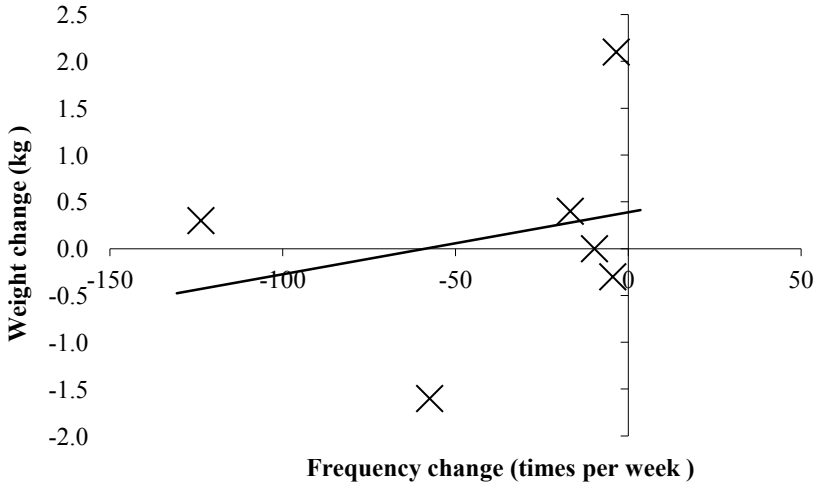


Figure 9.16 Change in weight estimated from change in frequency of ***snackfoods and calorific drinks within a meal*** maintained over three weeks. The regression line from weight change to frequency change has a slope of - 7 g/opw (Table 9.8).

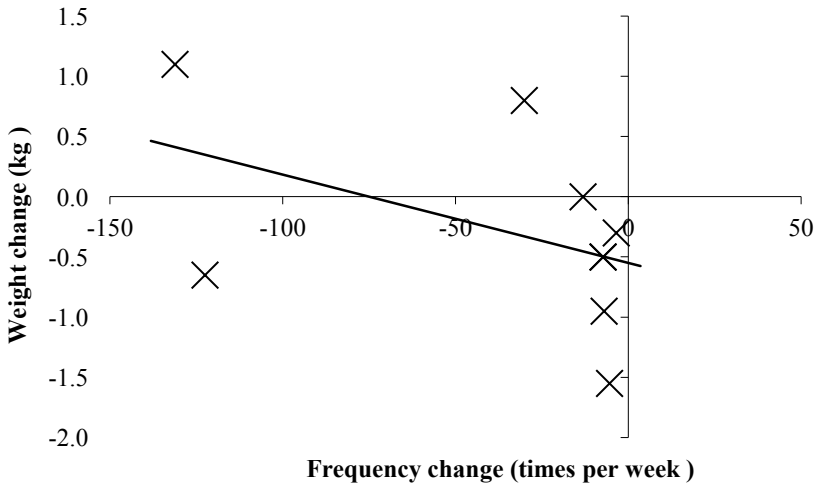


Figure 9.17 Change in weight estimated from change in frequency of ***snackfoods and calorific drinks between meals*** maintained over two weeks. Regression slope of 11 g/opw (Table 9.8).

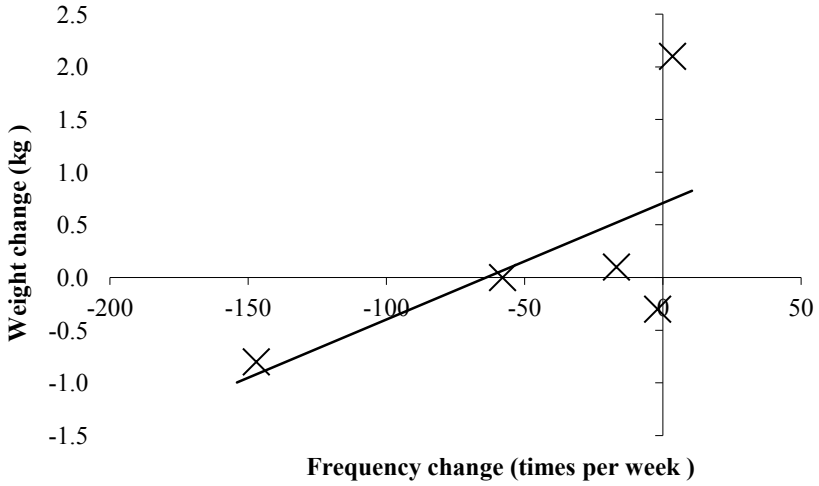
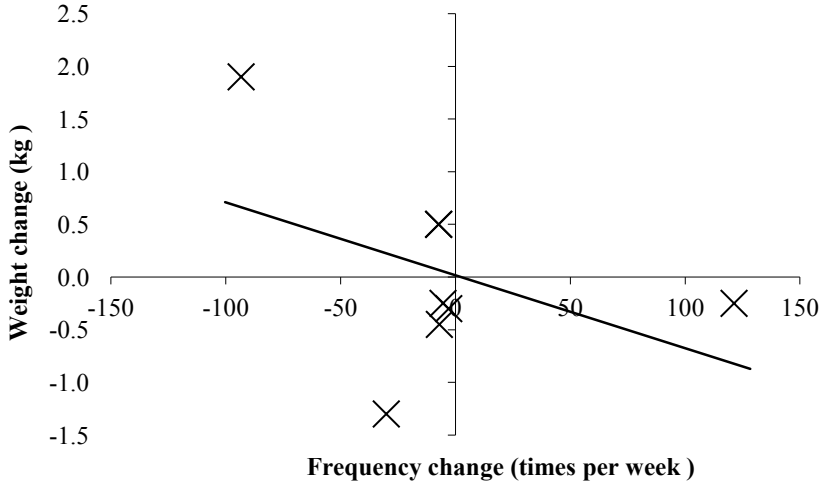


Figure 9.18 Change in weight estimated from change in frequency of ***snackfoods and calorific drinks within a meal*** maintained over two weeks. Regression slope of -7 g/opw (Table 9.8).



The change in frequency of snackfoods and calorific drinks between meals over the two-week period of largest effect was positively associated with weight change in that period starting a week later (Table 9.9, Figure 9.19, Behaviour lagged to weight). Similarly, the change from the first to the second week was associated with the change in weight from the first to the second week (Table 9.9, Figure 9.21, Behaviour lagged to weight). Regression indicated that the effect on weight of change in frequency was similar to the observed for the concurrent two week period (Table 9.9, Figures 9.19 and 9.21, Behaviour lagged to weight). There was no difference between correlation coefficient of lagged and cross-lagged changes in frequency and weight indicating no dominant effect of weight over behaviour. Since this change in frequency was response to a request, the expected direction of the association was most possibly from behaviour to weight.

Table 9.9 Time-lagged regressions of changes in weight and frequency of ***snackfoods and calorific drinks between meals*** over period of largest effect.

Figures no	Pre-dictor period	Time-lagged period		Behaviour to lagged weight				Weight to lagged behaviour				Differences	
						CLs of *b*				CLs of *b*			
			N	*r*	*b*	low	high	*r*	*b*	low	high	*z* score	1-tail *p* <
9.19 & 9.20	R0 to R2	R1 to R2	5	0.64	6	-11	22	0.66	230	-353	712	-0.04	0.48
9.21 & 9.22	R0 to R1	R1 to R2	5	0.65	6	-7	18	0.56	172	-389	734	0.14	0.44

Figure 9.19 Lagged change in weight estimated from change in frequency of ***snackfoods and calorific drinks between meals*** over period of largest effect. Regression slope of 6 g/opw (Table 9.9; Behaviour to lagged weight).

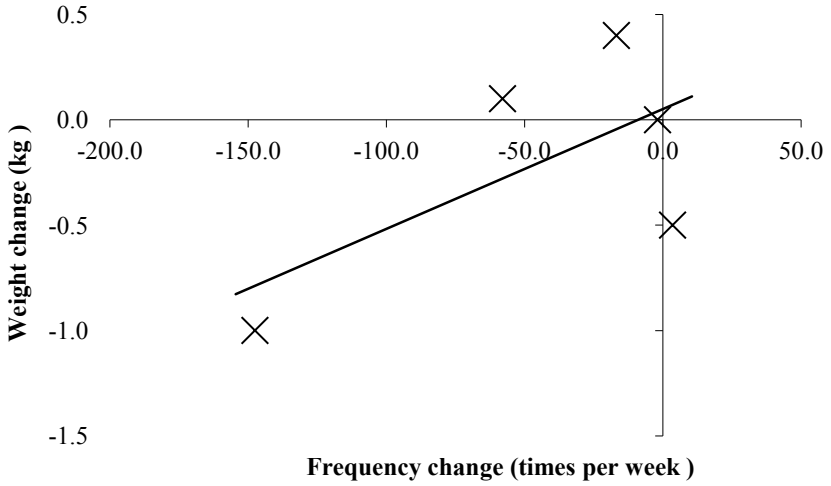


Figure 9.20 Cross-lagged change in frequency of ***snackfoods and calorific drinks between meals*** estimated from change in weight over period of largest effect. The slope of the linear regression (line through the data) gives an estimated effect of 230 times per week for an increase of a kilogram of weight (Table 9.9; Weight to lagged behaviour).

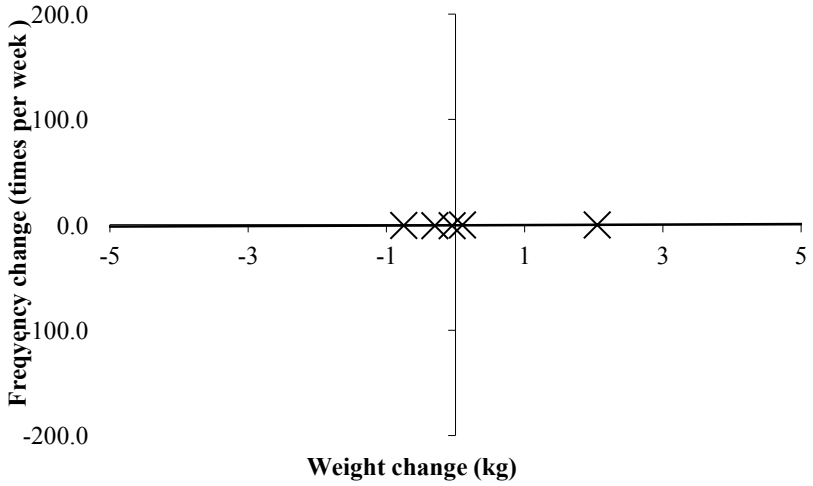


Figure 9.21 Lagged change in weight estimated from change in frequency of ***snackfoods and calorific drinks between meals*** over period of largest effect. Regression slope of 6 g/opw (Table 9.9; Behaviour to lagged weight).

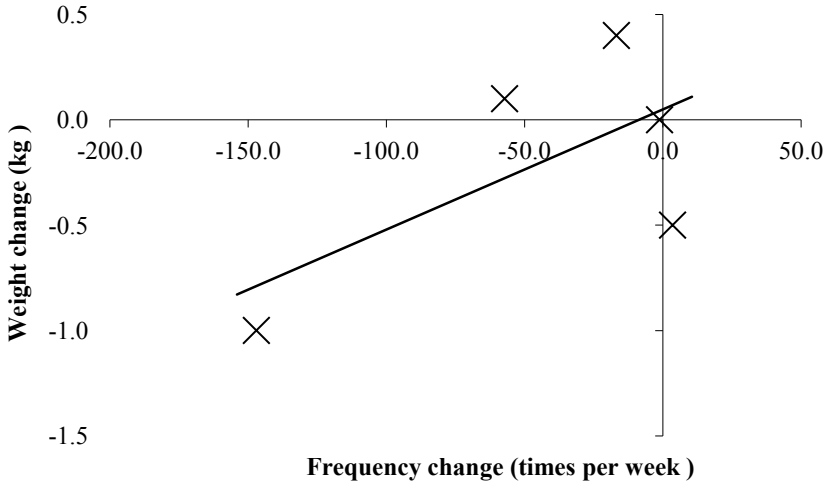
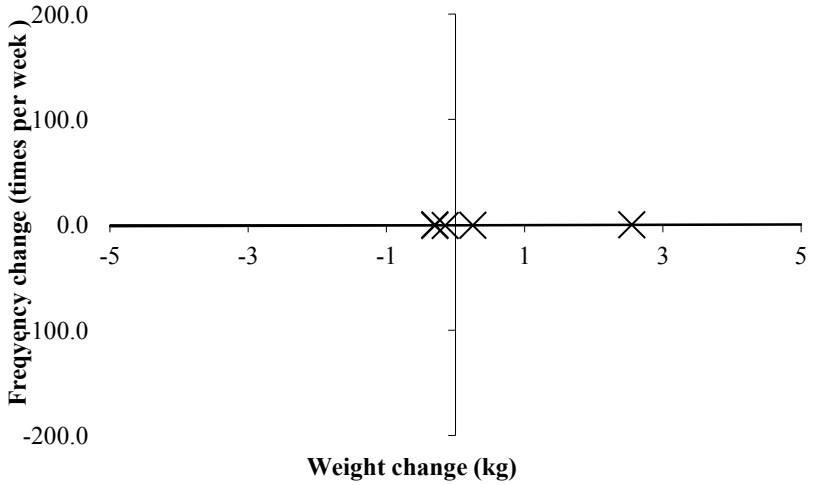


Figure 9.22 Cross-lagged change in frequency of ***snackfoods and calorific drinks between meals*** estimated from change in weight over period of largest effect. Regression slope of 172 tpw/kg (Table 9.9; Weight to lagged behaviour).



9.4 Discussion

9.4.1 Measurement of effect on weight of change in frequency of specific behahviour

This second tracking study met acceptably the main Thesis aim of measuring how much weight was lost when people agreed to change how often they carried out a common pattern of behaviour described in a generally recognised way (Figure 2.1). The set of findings were again consistent with a number of principles of the approach proposed in this Thesis (Chapter 2).

In particular, differences in energy exchange between experimental and control habits (2.7) were found in cases of participants who according to their records complied with the agreed change in frequency of a habit for enough number of weeks as to measure the lagged effect on weight attributed to a prioritised mechanism (1.7.1.1 and 1.7.1.2) operated or not by such sustained change.

9.4.1.1 Energy efficiency of fat

Lowering the proportion of fat in meals could reduce weight by lowering the energy content of the meals in a way that is not compensated, entirely at least, by increased energy intake in other meals. In theory, however, even at the same total calories, decreasing fat and increasing carbohydrate should increase the energy spent in depositing fat in adipose tissue (1.7.1.1). Hence, decreasing the frequency of meals based on fat-rich food could reduce weight even if the fatty meals are replaced by (carbohydrate-rich) meals containing as much energy.

In line with this hypothesis (1.7.1.1), the sustained decrease in frequency of high-fat meals prompted a decrease in recorded weight, reliably so by one measure even with $N = 5$ only. The reduction in frequency in high-fat meals of once a week caused at three weeks an estimated weight loss of 600 g. In theory, this is not a continuous but a stepwise effect achieved over three weeks when lean mass loss accompanying weight lost has compensated the decrease in energy intake by fewer fatty meals on a weekly basis than usual (1.5).

This slimming effect of reducing fatty meals was validated by the control habit. There was no evidence that fewer meals rich in carbohydrate generated weight loss. Indeed, an unreliably weight gain trend was observed with persistent decrease in frequency of carbohydrate-rich meals. This agrees theoretically with an expected reduction in energy expenditure from reducing intake of carbohydrates in meals (1.7.1.1). Although there are reservations about the assumptions of the design, this controlled experimental test did produce the predicted result from

a very small number of cases: the measure of a slimming effect was reliably greater for fewer "high-fat meals" than for fewer "high-carbohydrate" meals.

The experimental/control contrast to test for this efficiency of dietary fat at fuelling fat deposition relied on the correctness of participants' beliefs about the fat and carbohydrate contents of meals and a rapid equalising of their energy contents. This experiment included wordings that represent foods of fat-rich and carbohydrate-rich meals (Table 9.1). Hence, this gives an idea of the sort of meals that were possibly avoided by participants under each condition during the observed change in frequency (cp. Chapter 4). However, it remains necessary to investigate in the data presented or in subsequent studies what meals substituted both fat-rich and carbohydrate-rich meals.

9.4.1.2 Calories between meals

The claim that "zero-calorie drink breaks" are the first defence against weight gain (1.7.1.2) was supported by the finding that a requested decrease in the frequency between meals of recalled consumption of well recognised energy-containing items was followed over two weeks by a prompt decrease in recorded weight, as hypothesised for a maintained shift in energy exchange (1.5). The decrease in frequency by once per week caused a loss of 11 g. This "dose response" was in strike agreement with that found for same experimental condition in Chapter 8 (8.4.4).

In addition, when snackfoods and calorific drinks were consumed less often at meal, the control condition in this Chapter's experiment, there were no pointers to a weight-reducing effect of the change in behaviour. Indeed, eating these calorific items less often within meals could have been fattening, presumably because they displaced foods containing more energy or fat. In spite of that, the contrast between the slimming effect of eating snackfoods between meals less often and the potential slight fattening effect of eating snackfoods within meals less often produced a reliable difference between the two patterns in their effect on weight. This contrast between experimental and control conditions supports the theory that calories between meals are not so well compensated as calories (from the same foods) within meals (1.7.1.2).

9.4.2 Strengths and limitations of the findings

A lower number than expected of students taking part meant that the samples were not adequately sized for highly reliably associations between changes in behaviour and weight. A

likely reason for the high rate of drop-out from the first to second set of five reports was that most students had acquired all their participation credits by the middle of the Term. This did not necessarily indicate that the credits were needed to motivate participation because the research website to run this study did not allow continuing the participation beyond a specific number of credits per academic Term. Similarly it is not clear why no-one provided reports from among those across campus who expressed willingness to take part; there may have been technological disincentives.

The small sizes of samples precluded also a search for third factors involved in the causal relationships illustrated between change in behaviour and change in weight. In spite of that, this study found lower incidence over the tracking of spontaneous changes in frequency of habits due possibly to motivation to eat healthily or to exercise than in the first tracking experiment (Chapter 8). This indicates the usefulness of particular briefing to participants on keeping their habitual eating and exercise steady while self-experimenting on a habit.

The applied approach illustrates also the feasibility for people of changing the frequency of one specified pattern of eating or exercise at the time. This simplifies the approach of weight control relation to traditional approaches based on complex packages of dieting strategies (2.7). Indeed, according to the findings changing a few habits in succession will result in a weight reduction of clinical significance.

Although the inferred dose-responses are at present rough estimates of weight change by change in frequency of a particular pattern, they may not be too far from what actually happened in this sample of participants. The limitations in sample size or precision of records of weight and of occurrences of habits to estimate their frequency are compensated by highly focused design, measures and close tracking. The findings of the two tracking studies need substantiating in adequately sized samples but, as far the data go, having either fatty meals or snackfoods/calorie drinks between meals less often than usual reduced weight over 2-3 weeks. These examples alone of the potential power of the whole approach justify further development of such tests.

Once the evidence is available on how much a practice affects weight, the presented approach in this Thesis proposes a quantifiable outcome from a given advised behaviour change by indicating the amount of weight change estimated per each change in frequency in the target practice of once a week. By making objective for people the gains out the proposed behaviour change, the frame of the message would minimise subjectivity and any perceived risk (Smith &

Petty, 1996). So people can perceive as trustworthy the message of a behaviour change for a healthy weight that is clear and hence opt to do it (2.2).

In a similar way, to reduce redundancy between the patterns of eating and exercise that are monitored, the wordings of similar practices that are most effective require further investigation. For instance, in this study the participants agreed to eat fewer high-fat meals, whereas in the previous study (Chapter 8) some participants had low-fat meals more often. As discussed in Chapter 4, is there any difference in foods between the meals that are changed in response to these two verbally different but conceptually similar requests?

9.4.3 Participation in experiments on behaviour that controls weight

The data presented in Chapter 8 and in this Chapter 9 were provided by students who thereby met degree course requirements for participation in research. The evidence on how much change in which patterns produce a particular loss of weight is valid whatever way change in behaviour is induced. However, such motivation for taking part cannot be exploited generally. Crucially, any incentives (e.g. monetary) invalidate measures of persistence in change that are needed for relevant data on the effectiveness of different patterns.

More widely, any research that relies on participants' willingness to help the investigators thereby distances its results from what people would do for themselves. The most relevant source of data would be from people finding out for their own purposes what changes they can sustain and do reduce weight better than other changes. The investigators can guide them in the valid way to make such measurements for themselves, based on the experience in this Thesis of describing and tracking behaviour and weight. The research team can also provide readily interpretable feedback on their own findings as well as some interpretation involving data from other. That may be an additional incentive to make the necessary records.

Finally, such 'self-experimenters' can be provided the opportunity to share their own data with researchers who can make generally applicable estimates of effectiveness and maintenance of the changes in the specified patterns of eating and exercise. The last experimentally oriented part of this Thesis (Chapter 11) is a plan to implement the approach in that way.

PART F

LAPSING FROM A HEALTHIER FREQUENCY OF A PATTERN OF EATING OR EXERCISE

CHAPTER 10
PERSITENCE OF CHANGE IN FREQUENCY OF AN EATING OR EXERCISE PATTERN

10.1 Introduction

10.1.1 Aim

A weight-reducing change in eating or exercise has to be maintained in the long term in order for the weight to be kept off (Chapter 2, section 2.8). Lost weight is typically regained as energy intake increases again and extra exercise declines (Chapter 1, section 1.8).

The approach developed in this Thesis allows the persistence of a healthy change to be examined more closely than ever before. Weekly tracking of individuals' most recent uses of a specific pattern of eating or exercise can detect for the first lapse back towards the original frequency within a matter of days, to a precision of an hour or so. Hence information on the causation of that lapse can be sought from the participant's further memory of the reported event.

10.1.2 Approach

In the first tracking study (Chapter 8), the participants were asked to report weight and behaviour weekly before being asked to change an eating or exercise habit in a healthy direction. People whose attention has been drawn to their weight, eating and exercise in this way might want to change some of their habits immediately (2.8.1). Many people know which eating is considered to be healthy and which unhealthy (e.g., Chapter 3, section 3.3), hence any change in eating should be in a healthier direction at least, whether or not also being reputed to reduce weight. This was even more likely because the participants had been alerted that a change in a healthier direction would be requested. The weekly frequencies derived from reports before a request to change were therefore screened for such changes of eating or exercise in a healthy direction. Then those changes in frequency were tracked for the weeks remaining before a request to change was made, in order to detect any lapsing back in the less healthy direction.

The reported timings of each occasion of a monitored pattern included the day of the week and the time of day. Hence differences in the incidence of lapsing after different durations of maintenance could be sought between, for example, weekdays and weekends or different periods of the day.

10.1.3 Expected findings

Some hypotheses might not be testable because of a limited amount or variety of data. Nevertheless, the data can be inspected numerically for signs of evidence for or against a hypothesis.

Across habits and initial extents of change, there could be a variety of factors contributing to the first lapse from a change in frequency of a pattern of eating or exercise. One factor ending the maintenance of change might induce earlier lapses than another factor. If so, the incidences of lapses could be bunched in time since the initial change. If the timing of the effect of such an influence on lapsing were random, then the bunches of timings of lapse should be distributed normally, as well as each bunch having its own exponent in a log probability plot against the time interval from change to lapse (Poisson's analysis of a survival function: 5.1.3.1).

Each of these different influences on the lapse might be identifiable with a specific factor if sufficient were known about the surroundings of that event (2.8.3). The timing of the occasion that ends maintenance of change is the only dependent variable available for analysis in this Chapter. Nevertheless that datum includes the calendar day of the week and the clock-time for each 24 hours. Hence these days and times can serve as surrogates for factors in the context that may have contributed to the lapse. If a distinct influence operated more during the evenings or at weekends, for example, then one of the bunches of timings of lapse could be dominated by occasions at those times.

For example, the time on the clock informs people when to start an activity, such as a walk to work or the eating of a meal (1.8.3.2). Hence a day when the start of a long walk to work was late could trigger a reduction in exercise by use of transport. Another example could be awareness of approach of a mealtime could trigger a desire to eat at a time that was precluded by the original change in frequency of one or more eating habit.

Another example is that frequencies that can be maintained during weekday routines might be more readily disrupted at weekends. Any bunches in the duration of persistence would therefore be worth testing for a predominance of lapses at the weekend.

10.2 Method

10.2.1 Design

The experiment in this Chapter made comparisons within subjects of data selected for this Chapter's purpose from the tracking described in Chapters 8, where the method for collection of data is stated.

10.2.2 Procedure

Frequencies of eating and exercise patterns among students of Psychology at the University of Birmingham were estimated weekly from reported timings of the two most recent occasions of each habit (Chapter 8).

10.2.3 Analysis

The calculation of frequency from recalled timings of the two most recent occasions of each pattern and identification of frequency changes over time is described in Chapter 8 (section 8.2.7). This Chapter is based on the time interval between the first occasion of a sustained change in frequency of a pattern of eating or exercise in the healthier direction and the first occasion of a change back in frequency towards the initial level (the baseline). This lapse was assumed to be in the more recent occasion that contributed to the estimated frequency of the first week of lapse. The lapsing was identified as two or more weeks of frequency of a pattern changing back towards the less healthy direction.

The histogram of durations of maintenance was inspected for modes of high incidence. Each mode could also be inspected for fit to a normal distribution, as in Chapter 5 (Figure 5.3.1). The log probability function of survival of persistence in change was inspected for linear regions reflecting distinct causal processes, as described in Chapter 5 (5.2.4.2). As in that section of Chapter 5, regression analysis tested for the boundaries of each linear-seeming region of the maintenance-survival plot.

Each identified range of lapses was inspected for an unusually high incidence of weekends (Saturday and Sunday) or days of the working week (Monday to Friday) or of one of three six-hour periods of the waking day, 06:00 - 11:59, 12:00 - 17:59 and 18:00-23:99 (with any lapse between midnight and 6 a.m. being added to the evening). [With so few lapses to test, the six periods of the day used in Chapter 5 (section 5.1.2) were liable to produce many cells with very

few counts.] In a complete analysis, incidences of days or times of day would be contrasted with an even distribution among linear regions by χ^2 test.

10.3 Results

10.3.1 Incidences of durations of persistence

In participants tracked for at least five weeks, a total of 186 changes in frequency of different patterns in the healthier direction were observed over the monitoring period. In 29 such cases, the change in frequency was followed by lapsing. The incidences of lapses increased in certain ranges of duration of persistence, in what appeared to be normal distributions of incidence (Figure 10.1). By inspection, there were four periods in which the lapses were bunched. Objectively, the survival function did indeed have four linear regions, with ranges determined by regression to be 3-17, 20-26, 32-38 and 66-88 days (Figure 10.2).

Figure 10.1 Counts of times of persistence of change in frequency of patterns in the healthier direction.

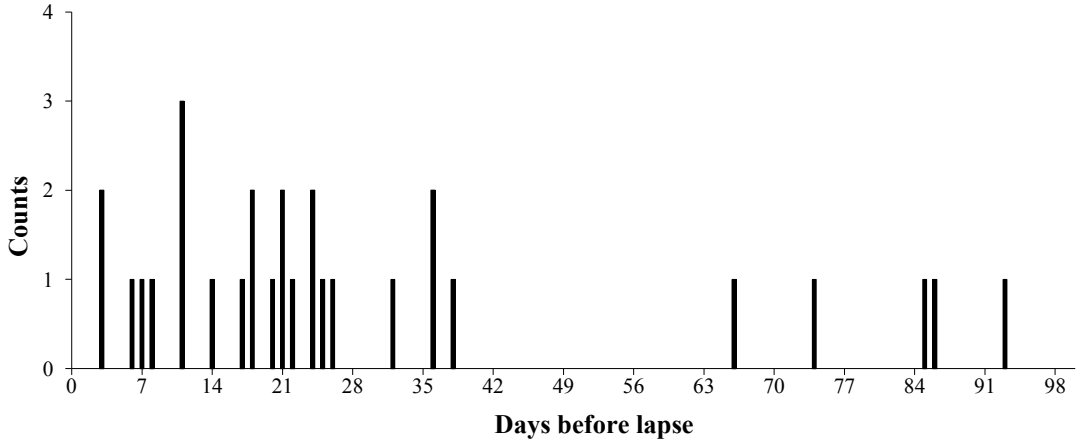
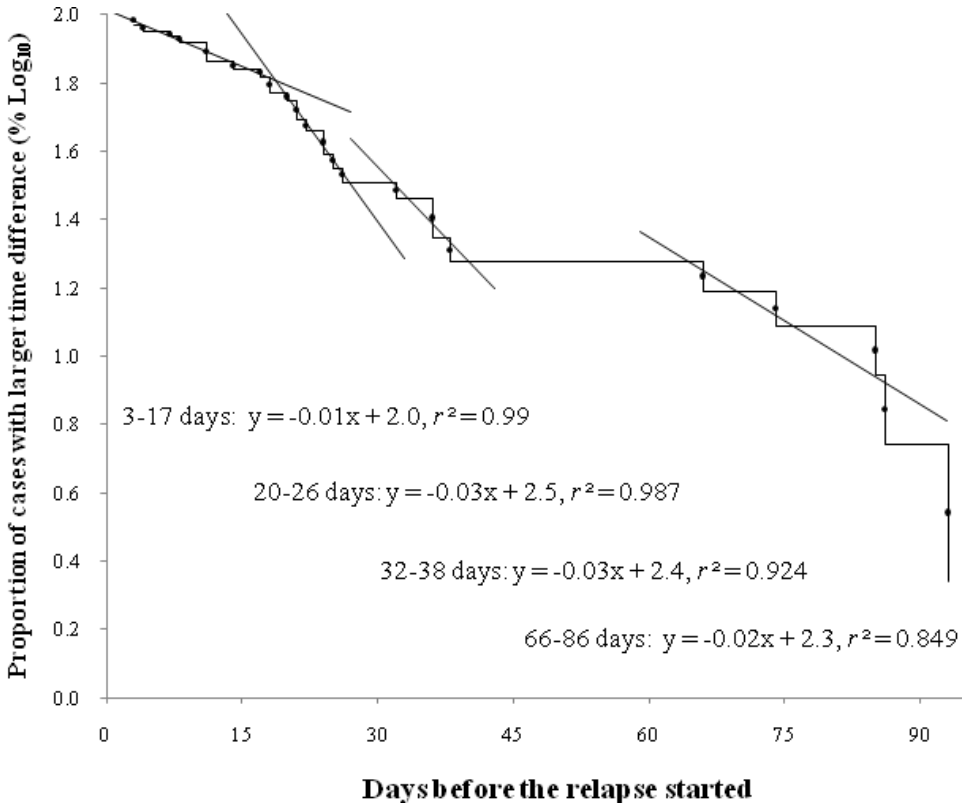


Figure 10.2 Ranges of days of persistence of spontaneous frequency change before the start of lapse (identified at fitted to straight lines).



10.3.2 Day of the week

With this small number of cases, the proportion of occasions of lapsing (or of initial change) during the working week did not vary reliably among ranges of linear decay in persistence (Table 10.1). Hence none of these distinct influences on lapsing could be identified with a context specific to the part of the week. Nevertheless, it might be noted that, in total, proportionately very few lapses occurred on the two weekend days out of the seven in the week.

10.3.3 Period of the day

The counts at the three periods of the day analysed did not vary reliably among the linear regions (data not shown). However, the longest persistence (66-86 days) appeared to be associated with lapsing (and initial change) early in the day (Table 10.1). All four of these late-lapsing habit changes were of eating.

Table 10.1 Variation among ranges of linear decay in maintenance period (Figure 10.2) in incidences in periods of the week (Monday to Friday working days *vs*. Saturday and Sunday weekend) and in time of day, for both the initial change in frequency in a healthier direction and in the lapsing from that change.

	Range (days)	*N*	Frequency change				Lapse from change				χ^2	*p* <
			work day	%	week end	%	work day	%	week end	%		
1	3-17	10	8	80	2	20	8	80	2	20	0.0	1.00
2	20-26	8	7	88	1	12	8	100	0	0	1.1	0.30
3	32-38	4	3	75	1	25	2	50	2	50	0.5	0.47
4	66-86	4	4	100	0	0	4	100	0	0	-	-
5	3-93 (all)	29	24	83	5	17	25	86	4	14	0.1	0.71

	Range (days)	*N*	Frequency change		Lapse from change		*t*	*p* <
			Mean	*SD*	*Mean*	*SD*		
1	3-17	10	14:30	03:48	15:36	03:48	-0.8	0.44
2	20-26	8	16:18	04:30	18:06	04:12	-0.8	0.43
3	32-38	4	15:42	02:42	16:48	03:30	-0.4	0.68
4	66-86	4	09:00	10:36	06:36	09:12	1.2	0.33
5	3-93 (all)	29	13:12	06:30	14:18	07:00	-1.1	0.26

10.4 Discussion

This Chapter illustrates the power of Poisson's analysis of survival function with multiple causes. Four types of error were identified and covered all the observed cases of lapses from healthy change. The identification of Poisson-linear durations of persistence shows that distinct influences affect lapsing, as was suggested from the literature on triggers of extra eating (Chapter 1, section 1.8.2 and 1.8.3). However there were too few data available to identify reliably any of sources of lapses with the context of either a part of the week or a time of day. With more data and deeper analysis, this method could prove highly productive.

The data provided no indication in support of a hypothesis that weekend activities are more disruptive than weekdays to the maintenance of a healthy change. Such an effect would be relatively unimportant in any case, because nearly all the lapses occurred during the working week. More cases are needed to substantiate any of these tentative conclusions.

More generally, the relatively small proportion of cases of reversal of a healthy change in frequency (16%) indicates that a good number of students can maintain their own chosen change for about two months during term time. This is in agreement with the idea that it is widely feasible to sustain change in customary practices of eating and exercise in order to maintain reduced weight (2.1 & 2.7). Research is, however, needed for investigating the duration of persistence of self-experimental changes in frequency of a specified custom of eating and exercise such as those investigated in the Chapters 8 and 9 of this Thesis.

Clearly, information is also needed on the specific context of each lapse. Since the reported timing purports to be of the most recent occasion, the participant may be able to recall the environment of that lapse. Participants may also have an opinion as to why they changed behaviour then. Such rapid follow-up of lapse was proposed in Chapter 2 (section 2.8) and is specified in detail in the plan of a complete experiment in Chapter 11.

PART G

THE DEVELOPED APPROACH TO MEASURING WEIGHT-REDUCING BEHAVIOUR

CHAPTER 11
DESIGN OF SELF-EXPERIMENTATION ON EFFECTS ON WEIGHT OF SPECIFIED PATTERNS OF EATING AND EXERCISE

11.1 Outline of the Chapter

This chapter presents the plan of a complete experiment using the approach specified in Chapter 2, investigated in particular aspects in Chapters 3-7 and illustrated in Chapters 8-10. The components of the two existing tracking studies that are retained without change in principle are merely cited and not detailed again. The focus below is on three additional aspects of the design that are intended to take the research as close as possible to the control of weight within a healthy individual's ordinary life.

First (11.2), the participant is given full responsibility for carrying out the experiments that measure the effect on weight of a change in frequency of a habit. Considered next (11.3) is maximum involvement of the participant in the multiple-baseline design. Finally (11.4) comes exploratory study of features of the environment that may have contributed to an observed return of a changed habit towards its original frequency – a 'lapse.'

The plan is written for use with students whose lives are sufficiently similar to those doing a degree in Psychology at the University of Birmingham. That is because nearly all of the new data collected for this thesis came from volunteers among that population. Nevertheless, the plan could be extended to members of the general public, particularly in Britain or at least around Birmingham.

11.2 Supported self-experiments

11.2.1 Aim

Participation in research in exchange for any form of extraneous compensation is liable to reduce the ecological validity of the findings. Hence ways need to be found for volunteers to conduct adequately designed experiments on themselves out of their own interest in the endeavour.

There seems to be widespread interest in helping research on changes in ordinary activities that keep weight down. Some evidence of this motivation came from the substantial number of people who expressed interest in response to a notice on the news page of the University's website (Chapter 9, section 9.2.3.1). Hence the aim would be to build on this interest in a way that sustains the frequent recording of weight and habits together with

changes in frequency of habits one at a time, in a manner that allows effects on weight to be calculated from combined records. Regular feedback on frequencies of tracked habits, graphed alongside weight, might satisfy curiosity sufficiently to prolong such self-experimentation, especially when the participant is shown that the personal records are necessary to the validity of the findings. Participants might also be motivated by contributing their records to a pool of data to generate evidence on what works for others in their circumstances.

11.2.2 Approach

The basic principle of this self-experimentation is that the single-case design with multiple baselines is run by each participant on her/his own habits and weight.

The plan is that volunteers agree to experiment on their own lives in return for a copy of the records that are required to see effects on weight of changes in specific activities. The research team provides each participant with readily understood feedback about individual progress and the frequencies of habits in similar people among recent participants. Each participant is shown the options opened up by the fed-back records, for experimenting both as interests them personally and also as permits fully controlled analysis of grouped data to measure the effect of each habit on weight.

The number of habits to be tracked is chosen by the participant, as is the first and second to be tested by alteration of frequency. The set of habits of that number offered to the participant is selected from the total available to suit grouped analysis of the data, as also is a preferred sequence of testing, with the participant being shown the rationale of equalising numbers of people testing each habit and balancing out effects of sequence. For example, if a participant elects for an initial option of tracking four habits, one common pattern of exercise could be coupled with three mutually exclusive patterns of eating.

The participant chooses which habit to change and from what day to change it, when weight has not changed recently, and decides on a change in frequency that can be maintained indefinitely.

11.2.3 Expected findings

Records shared by participants are expected to show one of the monitored habits at a time changing from a steady baseline towards a healthier frequency. In that case, concurrent variation in frequency of the other tracked patterns of eating and exercise will not be correlated with the changed frequency in the analysis of a set of records of change in the same habit (illustrated in Chapter 8).

It is also expected that any correlation across participants of change in weight with the change in frequency over the initial weeks will be accounted for by a greater correlation of the average frequency change with the total weight change starting after a delay than of weight change with frequency change after the same time-lag. Data that meet those conditions provide an estimate of how much weight is lost for a given change in frequency of the culturally specified pattern of eating or exercise (illustrated in Chapters 8 and 9). These estimates of effectiveness in weight reduction are expected to vary among the customs of diet or physical (in)activity.

11.2.4 Procedure

Much of the logistic detail of the conduct of the self-experimental study is the same as the tracking studies in Chapters 8 and 9. This section states only the changes in procedure that are critical to fully self-organised experimentation.

The opportunity to experiment on one's own ability to control of weight is advertised to the target population, referring potential volunteers to the briefing page of a versatile web questionnaire. That information about the research includes a graph of several tracked frequencies and weight. The frequencies are labelled generically as Eating or Exercise Habit A, B etc. and scaled in times per week at various ranges. There is a step change in one frequency and weight, followed by a maintained change in another frequency and a further change to asymptote in weight. Apart from those changes, all values vary slightly around a running constant.

The text explains that the volunteers fill in an online record at regular intervals of their latest weight on bathroom scales and the times they recall eating or exercising in particular ways. If they keep copying their records to the research team, they will be able to follow progress on a similar graph updated from their latest weights and frequencies.

11.3 Tracked multiple baselines with causal analysis

11.3.1 Aim

The individual is able to provide data from which the effect on weight of a change in an habitual pattern of behaviour can be validly calculated.

11.3.2 Approach

11.3.2.1 Frequency and duration of tracking

The change in weight after a change in the frequency of a habit is expected to take a few weeks (1.5). However, three records at any frequency is the logical minimum for time-

lagged analysis of the direction of causation. Moreover, in this project, some of the group mean weights were found to approach asymptote in the first report after the change in frequency of the habit (Chapters 8 and 9). Hence recording weekly may not be sufficiently often to catch causal processes between behaviour and weight as they happen.

Daily recording may be prohibitively laborious, and indeed could prove unnecessary. Intervals of 3-4 days could be considered. One day in the working week (Monday to Friday, maybe Wednesday) and another at the weekend (Saturday or Sunday) might be considered. Difference in eating or exercise between weekends and weekdays could then be picked up in recall over only 1-2 days, potentially yielding two baselines. More frequent recording would also increase the opportunities for cross-checking the recalled timings (and contexts) of events that are among the two most recent for successive records.

The experience with recording once a week indicates that experimenting with two habits in succession requires a minimum of 12 weeks once tracking has started (Chapters 8 and 9). A minimum of 2 weeks is required for baselines of weight and each habit's frequency (9.3.1). If weight takes 3 weeks to respond fully, a further two weeks of asymptote are needed before change in another habit can begin.

Those who fulfil an agreement to experiment with a minimum of two habits would be offered support in changing additional habits. Continued tracking would have the additional advantage of an increasing chance that asymptotes will not persist and lapses will be observed. The earliest lapse observed was 4 weeks after a request to change (Chapter 10).

11.3.2.2 Feedback of personal progress within the experimental design

As participants begin to share their records of weight and times of occasions of habits with the research team, they are sent an updated graphical presentation of the frequency of each habit and of weight (11.2.4 above). This feedback, after the initial briefing on the design to which it is the key, gives the participant the opportunity to conduct the experiment correctly on each habit.

11.3.2.3 Number of habits

Enabling a member of the public to persist in experiments within the multiple baseline design focuses planning on the necessities for data from which to estimate the effectiveness of eating and exercise habits in reducing weight. In Chapters 8 and 9, a considerable part of the requirement to cover the whole range of patterns of eating, drinking, movement and stillness was laid on the collection of data from each individual. In the event, however, the calculations of the effectiveness of each habit were carried out independently of those calculations on

other habits. Comparisons of effectiveness among habits were made among opportunistic subsamples from the same population. The stability of estimates from different samples needs to be investigated. It could also be feasible to compare habits pairwise at least within the same set of participants. Hence the number of habits monitored at one time by a single participant could be pared back to the minimum for multiple baseline control of two habits changed in succession. Furthermore, unlike Chapter 9, experimental and control pairs of habits, designed to test a mechanism, could be investigated by separate self-experimenters.

Hence this plan is open to the tracking of only about four habits by one participant, at least initially. Those who complete experiments on two habits, or even perhaps an experiment on just one habit, might be offered the opportunity to track additional habits and to experiment on some of them if they so choose. Since there appears to be considerably greater diversity of recognised distinct patterns in eating and drinking than in movement and stillness, a set of four habits might best be three of eating and one of exercise.

Quartets of habits could be designed to be comparable in ranges of frequency and likely attractiveness to participants for experimenting on. The different quartets could be offered in a randomised sequence to successive recruits. The preferred first habit to alter could also be randomised across trackers of a quartet, explained as a precaution against biases from sequence of changes in habits.

11.3.2.4 Multiple-choice responses

Much of the format of the tracking questionnaire could be the same as that used in the existing tracking studies (Chapter 8 and 9). However, the open-answer format used in the previous studies allowed errors in keying or format of the timings of occasions (6.3.3.1) or the readings of weight (7.3.3). Hence hierarchies of choices among button responses would be provided instead, if a web questionnaire were used (Tables 11.1 and 11.2). If a custom-built data-entry interface were available, then jumping over questions could be avoided by the program selecting the next appropriate array of labelled buttons to present.

11.3.3 Expected findings

An asymptotic weight reduction is expected while the frequency change is maintained over the weeks of monitoring (Chapter 8 and 9). Concurrent and time-lagged regressions between the two changes are expected to show a dominance of behaviour over weight at all intervals while weight is changing and the frequency change persists (9.3.3). The amount of weight lost for a change in frequency of once a week is expected to differ between habits. Chapters 8 and 9 were merely illustrative because of the small samples of participants.

The plan therefore is to continue recruiting self-experimenters until a habit had been correctly tested by a minimum of 25 participants (Chapter 8, section 8.2.7.7).

Table 11.1 Hierarchy of questions with fixed responses about the timing of an occasion.

Q. On what day at what time did you last start to [*pattern of eating or exercise*]?

A1. More than 4 weeks ago | Four weeks ago | Three weeks ago | Week before last | Last week | Earlier this week | Yesterday | Today

Skip A2 — *Please use weeks starting on Sunday* — *Go to Answer 5*

A2. Sunday Monday Tuesday Wednesday Thursday Friday Saturday

Please skip Answer 3 and go straight to Answer 5

A3. Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

If you remember the (approximate) date in the month, please write the number here:

A4. Never | More than 3 years ago | Year before last | Last year | This year

A5. 01-03 | 04-06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 00
hour period on the 24-hour clock

A6. 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55
minutes past the hour

Table 11.2 Multiple choice questions in a web questionnaire about weight in (a) kilograms or (b) stones and pounds.

(a) i. How many tens of kilograms do you read for your weight on the scales right now?

40 to 49 | 50 to 59 | 60 to 69 | 70 to 79 | 80 to 89 | 90 to 99 | 100 to 109 | 110 to 119 | 120 to 129 | 130 to 139 | 140 to 149

(a) ii. What is the units figure after that tens figure?

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

(a) iii. In what range is the reading as a fraction of a kilogram? i.e., choose 0.1, 0.3, 0.5, 0.7 or 0.9

0.0-0.2 | 0.2-0.4 | 0.4-0.6 | 0.6- 0.8 | 8-0.0

(b) i. How many stones do you weigh according to the scales right now?

6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19

(b) ii. How many pounds do you weigh within that stone?

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13

11.4 Factors in lapsing from an experimental change in frequency

11.4.1 Aim

The third part of the plan is to complete the experiment started in Chapters 8 and 9 by investigating the context of the first lapse from a change in frequency that was initially intended to continue indefinitely. The aim is to identify factors that discourage the persistence of changes in frequency, whether they are universal (2.8.3) or particular to eating or exercise, to a specific habit or to the direction or amount of change in frequency or intensity.

11.4.2 Approach

The first record of lapsing from a self-experimental change in the frequency of a habit is detected by a change in the opposite direction since the previous record if the direction of change has hitherto been consistent since the start, i.e. back towards the initial baseline (10.2.3). If the change has been maintained at a constant frequency or with small oscillations, then it may need two successive changes in the opposite direction to identify the start of lapsing. This gives the duration of maintenance of the change in the habit, to be included in the distribution across participants, to be subjected to survivor analysis testing for a number of discrete causal factors (5.2.4.2).

The timings of the occasions before and at the time of the record of the start of lapsing are then examined by the research team for an intrusion if the lapse is an increase in frequency or an omission if lapsing is frequency decrease. If a candidate intrusion or omission is identified, then the participant is asked specifically about that day and time. If not, the questioning is about any occasion that the (self-experimenting) participant might be aware of as an ‘extra’ or a ‘drop out.’

As at the start of every other aspect of this approach to research into life, the participant is asked first for her or his own account (2.2). S/he is asked if s/he can think of any reason why she might have done (increase) or not done (decrease) that activity at that time on that day (or whenever she might have). For example, the first question could be, “What do you think influenced you to do [*description of habit*] [*less* or *more* depending on what is the inverse direction to the healthy change] than in previous weeks?” with a box for textual entry

Then the putative lapser is asked for objective recall of features of the context of the intrusion or omission for which reasons have been given if possible. A Cognitive Interview technique is used, following a sequence of non-leading mnemonic heuristics (2.3.1). First come the mnemonics recommended to participants for reconstructing the timing of an occasion (Chapter 8, section 8.2.4), namely the location, timing, any people present and the

food eaten or the purpose of the moving around or sitting down. Then the participant can be asked for further features of the environment or of the personal state, especially anything unusual.

Finally, the participant is asked to evaluate for plausibility (*How likely is it that you were influenced by …?* from *certain* to *not at all*) each item in a list of hypothesised factors in lapsing (Table 11.3). The items include examples of factors extracted from published research of triggers of overeating, under-exercising or lapses from controlled use or abstinence with drugs such as alcohol, nicotine or narcotics (1.8.1). More specific subjective or objective factors, in respondents' own words, are added from pilot work on the first two stages of questioning about a lapse, after rapid extraction of consensus among a small subsample of participants (2.2). For illustrative purposes, wordings are included that were elicited as reasons for eating the reported meal in the study of healthy and unhealthy meals reported in Chapter 3.

This sequence of questioning is intended to end up with quantitative comparisons between wordings from broadly supported academic theory and (perhaps unsullied) personal experience.

11.4.3 Expected findings

11.4.3.1 Distributions of time from change to lapse

The duration of maintenance of an experimental change in frequency might be result of innumerable non-random influences. However, if some range of these persistence times is dominated by a single random determinant of lapses, then a linear phase could appear on a survivor plot (5.1.3.1). The time regions and slopes (exponents) of these lines might vary among habits across influences on lapsing or among influences across habits.

11.4.3.2 Causes of lapses

Consensus on words or concepts in reasons for lapsing or recalled contexts of lapses is sought in interviews with a small number of participants in the first instance (3.2.4). Cases of these constructs are liable to vary in incidence, distinguishing more common factors from less common. A high-incidence factor might be distributed unevenly among habits, relative to the distribution of all other factors (5.2.4.3).

Such a word or concept would be identified as a discrete influence on duration of maintenance if its incidence in the range of durations for a straight line in the survival plot,

Table 11.3 Wordings for subjective and objective factors that may lead to a lapse from a change in the frequency of a habit (1.8.1). Italics: words elicited as reasons for taking a healthy or unhealthy meal in Chapter 3.

Category of hypothesis	Personal wording of the motivation	Description of the environmental factor
Weight targeting	disappointing rate of weight loss; losing weight not urgent	*no weight change*; lost 1 lb in 2 months
Return to habit	feel used to doing it	often did it prior to change
Breakdown of dietary restraint	couldn't keep up limiting my eating	persisting use of low-fat version
Dietary deprivation	very *hungry*, need *filling up*	unsatisfactory meal
Food options	*not tasty*; *don't like it*; not *exciting*	lack of variety; *only access to fast food*
Temptation	crave that food	*tasty* food item seen or smelt
Addiction	must watch my TV programme; cannot stop thinking of food	TV schedule seen; stock of craved food at home or office
Emotional state	*stressed*, *upset*, *grumpy*, *bored*	annoying person; unexpected delay
Fatigue (mental)	too complicated; can't be bothered	no ready-made facility; work many hours
Fatigue (somatic)	too tired to go to gym; needed sugar to keep me going	unusual amount of physical activity; lack of sleep
Social facilitation	joined in; *others eat that way*	people present who are eating / sitting friend picked me up for lunch / walk
Money	mustn't waste money	not *being in budget*; someone else paying food bill / gym membership
Time constraint	too late to walk; too busy to cook	transport available; *miss lunch*; *only access to fast food*
Time of day	can't miss my midmorning biscuit	usual time for a meal or break from study
Complexity of task	*not practical*, takes a lot of organising	facilities require arrangements
Location	sports centre too far from home	lift nearer than stairs; eating out; near a take-away

relative to the incidence outside that region, were greater than the relative incidence of all elicited factors. These identifications might also vary across the habits experimented on.

11.4.4 Procedure

The questionnaire about factors in a lapse is presented to the self-experimenter as soon as a putative lapse is detected in the records. If the frequency continues further in the opposite direction to the experimental change, additional lapses are sought in the recalled occasions from the timings of which the reversal of frequency had been calculated. The questionnaire is presented again as soon as possible after a further lapse.

11.5 Results and Conclusions

The above aims, designs, expected findings and procedures constitute a plan that could be executed by an investigator in a team having the time and facilities. Presentation and evaluation of findings will have to wait until the data are available from such an experiment.

PART H

CONCLUDING DISCUSSION

CHAPTER 12
FUTURE RESEARCH AND PRACTICE

12.1 Implications of this research

The approach under development in this Thesis provides an innovative framework for future research into effective control of body weight (Chapter 2). The key principle is to measure the effect on weight of a change in how often a person performs a locally described pattern of eating or exercise. This framework comprises diverse components; the author has investigated these one at a time and articulated them into an experimental design that tracks influences on weight within the individual's ordinary life.

The novelty of the approach means that one doctoral project is far from sufficient to establish the framework. Substantial further research is needed to develop each component fully. Furthermore, different components involve biological and/or social science, as well as distinct aspects of psychology. Thus, multidisciplinary research teams will be needed to implement the approach effectively. The teams will also need developers and maintainers of internet facilities for monitoring the weight, habits and circumstances of large numbers of people, linked to extensive computation on the information coming in and going out.

This concluding Chapter of the Thesis first reviews the further research needed on the various components of this approach. It then considers implications for the public's practice of healthy control of weight and for the health professions' contributions to the reduction and prevention of obesity.

12.2 Future research

12.2.1 Measurement of weight

An individual's current weight will remain central to the prevention and reduction of unhealthy fatness, at least until such time that every home has an instrument that accurately measures the fat content of the body. Most of any persisting change of weight is an alteration in the fat stored in and around the abdomen. These deposits contribute to and mark risks to health from degenerative conditions such as high blood pressure, diabetes and clogging of the arteries with cholesterol. Measurement of height in addition is necessary to the body mass index (BMI) for assessment of overweight and obesity in adults but height does not change when body fat content is altered. The circumference of the waist may be at least as good as BMI as a predictor of percent body fat. However, centimetres of waistline change more slowly than (half) kilograms of weight and are much more difficult to measure accurately.

The present project's use of participants' frequent records of their readings from domestic scales is a groundbreaking approach for obesity research in free living individuals. Additional research is needed to identify aspects of repeated self-weighing by members of the public that improve the accuracy of measurement of changes in weight of the body that depend on its contents of fat. Research would benefit from automatic recording of a stable reading. Apart from the weighing scales themselves, however, the scope for improvement is in the performance of the procedure of weighing and also of the instructing in best practice of the people taking their own weights (2.4).

Quantitative assessment is needed of the importance of variations in readings on the scales that can come from clothing, the contents of the digestive tract and bladder, and recent loss of water through breathing and sweating (2.4). These variations need to be studied at widely usable times of day, such as when preparing for bed at night as well as when rising in the morning. The scales must be positioned correctly and the readings have to be legible. The wordings of instructions also need to be compared for effectiveness at instilling a standard practice of weighing and recording the reading at the appropriate frequency.

12.2.2 Measurement of energy-exchanging behaviour

12.2.2.1 Identification of customary patterns of intake and expenditure of energy

An even more radical innovation than the recording of readings from weighing scales at home is the use of patterns of behaviour described as agreed among members of the public (2.2).

The first step in research into any such customs is to determine the words in which they are referred to by residents in a locality or by members of a subculture there. Hence the present research should not be criticised for lack of generality. It has to be a separate subsequent step to identify customs in another locality and/or culture.

Nearly all the data in this thesis came from students in the School of Psychology at the University of Birmingham. Probably most of them were brought up in Britain. Indeed, a substantial minority may have come from the Midlands (of England). Key parts of this work were based on descriptions of behaviour by more diverse samples from this geographical region. The new data on wordings in Chapter 3 came from potential applicants to study Psychology at the University and the relatives and friends who accompanied them. The standard wordings used in Chapter 4 came from questionnaire items that had been created by merging descriptions of healthy practices elicited 20 years previously from members of the

public in the West Midlands. Future research of this sort in this University's locality will need to re-establish descriptions of common relevant habits in the majority culture.

Further work on the wordings for patterns of eating and exercise is desirable even for research confined to university students in the English Midlands. This includes full narrative directly from students not previously involved in research of this type, about occasions of eating, drinking, moving around, sitting and keeping warm or cool. Students' consensus on what wordings refer to the same sort of occasion could be elicited by cluster analysis of rated differences between all pairs of wordings, or by the simpler but more restricted comparison of new wordings with a previously used set as in Chapter 4.

12.2.2.2 Quantification of the frequency of a pattern

A change in the amount of energy stored in the body results from a difference between the amounts of energy going into and coming out of the body over a particular period of time (Chapter 1, section 1.5). That is, fattening or slimming does not come from the amount of calories ingested in food and drink or spent or conserved in movement, stillness and keeping at a comfortable temperature, e.g. a number of kilojoules. Change in weight comes from a persisting difference between the rates of intake and expenditure, in average kilojoules per day for example.

Hence, if the amount of energy ingested or spent in an identified habit of eating, exercise or keeping warm or cool is generally about constant, what matters for change in weight is persisting alterations in how often that pattern is executed (Chapter 2, 2.3.2). Realistic estimates of the frequency of a particular sort of event entirely depend on the stated timing of every occasion of such an event. To avoid the labour and distorting effects of making a record of each occasion, the record has to be constructed from autobiographical recall of the event (2.3.1). Further research is needed on the use of unbiased prompting of recall to minimise confusion between similar occasions at different times. In this project, participants were encouraged to think first where the event occurred and who was there. Would variation among repeated recalls of the same event be less if such cognitive strategies were used each time a pattern was asked about?

It might be useful for calculations of impact of a habit on weight to allow for inaccuracies that grow with delay from event to recall, for example by putting less weight on estimates of frequency based on timings of occasions further in the past. The present work included comparison of accuracy of recall between occasions one and two days previously, with no clear difference found (Chapter 5). Further back within the working week, e.g. four or

five days, should be investigated, as also a period including the same day of the week as that of the recalled occasion, i.e. 10-12 days previously.

Other approaches could be compared for accuracy with the calculation of frequency from the recalled timings of the last two occasions. For example, if the monitoring were frequent enough, time from the last occasion to the occasion of recall might provide a sufficiently accurate frequency estimate and a prompter alert to a change in frequency. Participants might find it easier, with little loss of accuracy, to be required first to recall the two most recent occasions but then to respond with the number of times in a week, month or year that such an event currently occurs, as usual in frequency questionnaires.

12.2.3 Effects of particular customs on weight

12.2.3.1 Specification of a habit

A set of potentially effective habits needs to be specified for each locality in that culture's terms in their physical and social contexts. Nevertheless, full-scale 're-localisation' might soon prove to be unnecessary. Commonalities in behaviour and its description might emerge across regions, communities and even languages, allowing at least a core of standard wordings to be developed with minor adjustments in vocabulary, as in psychometric instruments that are in international use. Variation in a custom's effect on weight across environments is of course an additional question, especially if foods differ greatly in composition of energy nutrients or portion sizes and if there are big contrasts in transport systems, building interiors and leisure facilities.

There is likely to be a large number of eating and exercise customs that require testing for effect on weight. Future research might use a variety of approaches to this logistic issue. Different customs can be tested in succession in an individual monitored for a considerable length of time. Alternatively, to test several customs in a short period of time, one or two different customs can be tested in each subsample of large pool of participants.

12.2.3.2 Multiple baseline measurement of changes in habits

Another innovation in basic research on weight control was to implement the single-case experimental approach developed in the early days of behaviour therapy (2.7). This design breaks up the complex packages of advice on weight control into particular sorts of habitual activity. It then becomes possible to gain insight into the causal links between any specified pattern of eating or exercise and weight at the biological, cognitive and social levels.

More research is needed to integrate the use of multiple baselines with experiments by members of the public on the effects of changes in their own habits. In particular, this approach should be taken to psychological investigation of how people make changes in their ordinary life. For instance, psychometric questionnaires about the motivation of change and its maintenance can be complemented by quantitative use of consensus wordings from the target population.

12.2.3.3 Causal direction of correlated changes in weight and a habit's frequency

The present approach estimates how much a habit contributes to weight control by testing hypotheses about specific influences on weight, one at a time (2.6). Hence the concurrent and time-lagged analyses apply simple (single-predictor) linear regression, instead of the multiple regression (with cross-multiples for third factors) that is used in exploratory analysis ('Granger causality'). Also the number of measures in a time series is only as many as required to test the hypothesis, i.e. adequately frequent repetitions over the few weeks that the change in weight is expected to reach an asymptote while the change in frequency persists, rather than the lengthy time series that are generally favoured for causal analysis (1.5).

The approach is fully valid when the average change in frequency until asymptote in weight regresses reliably onto reduction in weight beginning after the start of the change in frequency, without a correlated change in any other monitored habit or a reliable regression over that whole period from the weight change to a frequency change starting later (9.3.3). The results are more difficult to interpret when the cross-lagged regression is reliable or there is evidence of a third factor causing both the change in weight and the change in that habit (e.g. 8.3.7). The simplest tactic is to subtract the cross-lagged and third-factor coefficient from the coefficient of the regression from behaviour change to a later-starting weight change, the strongest regression would indicate the dominant connection.

However, in principle such confounding cannot occur if the multiple baseline design is strictly followed. Therefore future research should focus on mutually exclusive description of habits and the disciplined execution of a change in only one habit at a time.

12.2.3.4 Amount of weight change resulting from a change in the habit's frequency

When there is little or no correction of the regression from a habit's change in frequency to time-lagged weight change, the slope of that regression provides an estimate of the "dose-response" of amount of change in weight for a given frequency change (9.3.3). Confidence limits need to be put on these estimates for the purpose of comparing the

effectiveness of different habits. The sensitivity of the estimate to known conditions also needs to be investigated by comparisons within the sample. For instance, does the slope of that regression depend on how big the change from baseline in frequency or weight was initially or is at the end of the period used in the regressions?

Wider questions can be asked when there are enough data. For example, does the dose-response slope differ with the direction of change in weight, i.e. between an experimental change in frequency and a persisting lapse from that change? Is there a greater or less effect of frequency change on weight when the habit is the first to be changed than when it follows one or more other habits' changes or after change in a particular other habit?

12.2.5 Persistence of change and causes of its ending

For a reduction of an overweight or obese person's weight to lower the risk of disease, the weight must remain off for many years (2.8). Hence the change in frequency of a habit that contributes to a loss of weight must be virtually permanent or at least replaced by sustained change in another weight-reducing habit. It remains to be seen how well maintained are changes in frequency that self-experimenters or requested participants judge that they can continue indefinitely (or for experimental purposes at the minimum) in habits that they have selected to test on their weight. Hence a key part of future research will be at least intermittent monitoring for as long as possible of all the habits with changed frequencies, in order to detect any change back towards the frequency before the experimental change. The more frequent is the continued monitoring, the more accurate will be the estimates of duration of maintenance and the better the chance that the occasion of the lapse is recent enough to be recalled clearly.

Even fully informed and freely chosen amounts of change in frequency or intensity of a habit shown to reduce weight may not always be maintained indefinitely. On that assumption, understanding of influences on lapsing from such a change is a key element of the research approach, for application to the prevention of lapsing.

There could be conventional analyses of candidate predictors of maintenance and drop-out, such as initial BMI, dietary restraint scores and so on. Scientifically and practically more valuable would be survival (Poisson) analysis (as in Chapters 5, 6, 7 and 10), to determine if there are discrete types of influence on failures of maintenance and focusing the collection of extra data onto recalled influences on lapsing (Chapter 10 and section 11.4). That is, the factors that trigger lapsing can be investigated as their influence operates on the behaviour, rather than in a generalised retrospect or prospect (1.8).

This evidence can then be used to develop environmental and personal strategies to avoid or reduce factors in lapsing and thereby help to maintain weight loss (see 12.3, below).

12.2.6 Exchange of energy between the body and the environment

The present approach takes J.S. Garrow's theory of obesity and weight control (1.5) out of the laboratory and clinic at last and into people's everyday lives. Its thermodynamics and physiological science have begun to be linked to the cultural anthropology through the behavioural and cognitive science. Much remains to be done.

12.2.6.1 Differences between habits in energy exchange rate

The basic method of frequent monitoring of weight and the frequency of each of a set of habits (2.5) can be used to provide a foundation of scientific evidence for building a coherent programme for long-term control of weight within or at least towards the healthy range.

First the most effective habits can be identified in words that everybody understands sufficiently. Then the changes of frequency that are most readily maintained in current circumstances can be determined. Finally some system can be devised of conveying that information in ways that are known from the evidence to be usable. The most obvious principles of caring for weight are to attempt maintainable changes in frequency of one or two proven effective habits at a time, in a succession that spans the individual's usual habits of eating and exercise.

The flexible system of personally tailored and cultural attuned intervention can then be tested for long-term efficacy by conventional controlled trial. However, the effort and resources going into such a trial would be better used by including the close tracking of behaviour and weight and measurement of the effectiveness and feasibility of each changed habit.

12.2.6.2 Rate of energy intake or expenditure at a frequency of each habit

The basic measurement of the effectiveness of a habit provides opportunities for more fundamental research that remains relevant to ordinary life. Research settings should be devised where it is possible to measure fat and lean masses when weight and the frequency of a habit are changing and are maintained at their asymptotes (2.5).

In addition, for each occasion of the execution of an eating or exercise habit, for example, the decreases in rate of energy intake given into kilocalories could be estimated, by automatically recorded weights of coded items of food and drink and the increases of energy

expenditure by portable sensors that record the movement of the human body (i.e. triaxial accelerometry) or by measuring in a respiratory chamber the body heat from quantification of intake of oxygen and release of carbon dioxide or nitrogen (i.e. indirect calorimetry).

Such measurements would help to increase the understanding of the impact on rate of energy intake and expenditure of different compositions of customary meals and varieties of physical activity and inactivity. Such knowledge could be used to go beyond the description of effects of diets or exercise regimens to research designed to explain the mechanisms of action of the ingested food or the muscular contractions (1.7).

Such advances in theoretical knowledge would strengthen the framework for investigations of the mechanisms by which different medications or surgical interventions act on the control of weight.

12.3 Implications for treatment and prevention of obesity

12.3.1 Preventative education

Clinical prescription and advice on weight reduction, and healthy lifestyle more generally, depend on a background of messages to the public through the media. Indeed, brief clinical intervention is usually couched in those terms. Nevertheless, advice to eat healthily and to exercise sufficiently is intended for everybody, whether or not they already have medical problems caused or exacerbated by overweight or obesity.

Substantiation of findings like those illustrated in this Thesis by further research would provide a basis for reconsidering the terms of messages that could help to prevent the onset of overweight or its worsening into obesity. The messages should communicate clearly what changes in common habits actually do deliver weight loss, as well what factors trigger relapses (2.2). For example, after future research has clarified which timings of energy intake between what the public regards as *meals* produce less compensatory reduction of energy intake, the fattening timings of food intake could be given more prominence among the warnings about fattening nutrients and foods, using the vocabulary that the research has shown communicates the specific habit most precisely.

Official messages could thereby gain a reputation for pointing to effective control of weight (2.2). Then those wordings would be more liable to be adopted by media professionals and in word of mouth among the public. People who attend to clear messages that are found to be trustworthy can also contribute to consideration of ways to re-shape the environment to

be effective for more people in sustaining practices that keep weight in the healthy range (2.8.1).

12.3.2 Clinical practice

The approach to research into behaviour influencing weight under development in this Thesis (2.1) has close parallels to the best efforts to reduce obesity through clinical practice that are made by dieticians, hospital and community physicians, bariatric surgeons and other health professionals. Indeed, an automated system of carrying out such research could readily spin-off an internet tool for use by a health professional, with the client's (patient's) permission, to advise on and to monitor lifestyle modification in order to reduce weight healthily and to maintain the reduction.

In contrast to the advice on diet and exercise traditionally given by clinicians, the application of results from this approach to research involves the simple and concrete advice to eat or exercise in a particular way, either less or more often than at present (2.7). The advice is given in terminology that enables the client to recognise clearly the behaviour that needs to be changed (2.2). Furthermore the evidence for the effectiveness of that change has been obtained from participants living within the same physical and social reality. Even better, that evidence is that the current environment can provide support for the advised change, because a good number of others are already using the habit at the healthier frequency.

This research provides direct evidence on the effectiveness of some components of existing packages prescribed to overweight patients and on the most appropriate words in which to communicate such advice. More importantly, it provides the basis for a potentially much more effective approach to all treatments for obesity.

The identified effectiveness of each habit in reduction of weight is a reference point for clinical judgments on how far weight would be reduced by a given change in the frequency of the prescribed habit. To tailor a feasible extent of change for the participant, the ranges of frequency of that habit in the locality can be taken into account from the evidence gathered by this sort of research (Chapter 8, 9 and 10). After the asymptotic weight reduction from a frequency change in a habit is achieved, a new change can be introduced. Although the weight reduction from a sustainable degree of change in a habit is modest, e.g. 0.5 – 1.0 kg, maintained changes in a few habits should achieve a clinically meaningful reduction in weight and body fat.

Clients could also be informed from direct evidence about the potential factors that lead to a lapse from the change in a particular habit or a number of habits. So, those who implement such a change can look for ways to escape or avoid circumstances likely to trigger a lapse and can seek to create conditions that facilitate maintenance of the change in behaviour and hence the weight loss. Clearly, research alone cannot change clinical practice or public health implementation. Nevertheless, approaches like that illustrated in this Thesis are an essential part of the basis for improving the effectiveness and efficiency of professional delivery, as well as one of the means for evaluating the outcomes of the changes introduced.

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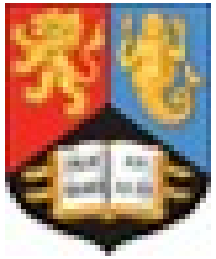
ANNEXES

EXAMPLES OF MATERIAL PRESENTED TO PARTICIPANTS



Annexe to Chapter 3

UNIVERSITY OPEN DAY

Would you like to help us?

Research on Healthy Eating

Five or so minutes
answering a few questions
about what you do.

University Open Day, School of Psychology

An example of unhealthy eating

Date: Time of day: Male / Female Adult/Youth/Child

1. Please describe the last occasion when you ate in an *unhealthy* way.
When (date and time of the day)? Where? With whom? What sort of eating/drinking occasion was it? What did you eat and drink? (with rough quantities).

2. Was that the most recent occasion that you ate this way? Yes / No
If no: when was the last time you did this?
Time of day. Day of week + no. of weeks ago OR day and month.

If yes: what was the day and time when you last ate that way?

3. What would make it more likely and what would make it less likely that you would eat that way again in future?

a. A factor that would make it ***more*** likely

Description of the influence:

What level of this influence would ***most*** encourage you to eat in this way?

What level would only encourage you slightly?

b. A factor that would make it ***less*** likely

Description of the influence:

What level of this influence would ***most*** discourage your eating in this way?

What level would only discourage you slightly?

c. Any other factor that would influence you – please describe it:

At its most influential?

At its least influential?

Thank you very much for taking part in this study!

Annexe to Chapter 4

Dietary and exercising strategies for weight control specified by informants from the study population (Blair, Booth *et al*., 1989)

1. Limit amount of food eaten and drunk at meals (e.g. have small portions, no second helpings)
2. Do vigorous exercise regularly (e.g. sport, aerobics)
3. Go to a slimming club or weight-reduction class
4. Stick to the same number of calories every day
5. Eat few nuts, crisps or other high-fat snackfoods
6. Walk or cycle whenever possible
7. Drink little or no alcohol
8. Add little or no salt to food when cooking or at the table
9. Eat slimmers' meal replacements for one or more meals a day
10. Avoid fat in cheese and cream (e.g. eat low-fat or cottage cheese, yoghurt rather than cream)
11. Avoid sweet 'extras' (biscuits, cakes, sweets, chocolate)
12. Avoid unnecessary fat in meals (e.g. avoid fatty and red meats, avoid frying, remove oil before serving)
13. Eat food high in fibre (e.g. wholemeal bread, bran cereals)
14. Fast or miss out meals completely
15. Eat food high in polyunsaturates (e.g. seafish, soya/sunflower spreads)
16. Avoid calories in drinks and snackfoods between meals
17. Avoid losing vitamins when preparing vegetables (e.g. do not peel vegetables, do not overboil vegetables)
18. Be strict about your eating style (e.g. have small mouthfuls, eat slowly, do not eat when doing something else)
19. Avoid unnecessary fat when using spreads (e.g. use low-fat spread rather than butter or margarine, spread thinly)
20. Choose foods and drinks low in calories at main meals
21. Avoid sugary food (e.g. tinned fruit in syrup, sugar with cereals, beans with added sugar)
22. Eat small amounts of starch (e.g. bread, potatoes)
23. Avoid sugar (e.g. use a low-calorie substitute) in coffee/tea
24. Whenever possible, choose food and drink labelled 'reduced-'or 'low-calorie'
25. Eat fresh fruit and salads instead of higher-calorie foods
26. Use skimmed or semi-skimmed milk instead of whole milk
27. Eat meals at the same time each day

Examples of actual eating occasions of either healthy or unhealthy described by visitors to the School of Psychology of the University of Birmingham during the Open Day in 2008.

Healthy	Apple, yesterday lunch time with my friends and I also had a bottle of water.
	Dinner, at home with the family. Boiled vegetables with a fresh soup and bread.
	Had a large typical English breakfast with my sister-in-law. Ate - hash brown, beans, toast & tea.
	Breakfast at home with my dad. 2 slices of toast with raspberry jam and a glass of water.
	Low fat meal. Evening meal with the whole family. Vegetarian casserole with pulses, tofu, vegetables. Drank water.
	Formal ball, Sudley castle, with country people. Drank water, fish, fruit, salad.
	Last night, meal out with friends, ate soup, vegetable stir-fry, mushrooms and fruit, drank water and shots.
	Evening meal at home on my own. 1 plate pasta and pesto and salad and fruit juice 200ml.
	Lunch time at college with friends. Cheese sandwich, brown bread, 1 apple, water (1 glass).
	Preparation for a sporting event. Breakfast. At home on my own. A bowl of oat and bran porridge with a tall glass of water.
	Family meal. At home. Husband, son daughter. Green salad starter plus oil: balsamic vinegar; chicken breast, couscous, fresh fruit salad, 1 glass of white wine, 1 mug coffee.
	Breakfast 8:30 in the kitchen. With husband. Bowl of muesli with milk. Mug of tea.
	Thursday lunch at home with my wife: I ate a salad with cheese and some pickles plus yogurt and drank a cup of tea.
	Breakfast, my house, alone, I ate Bran Flakes w/nuts. 50 grs skimmed-milk.
	Yesterday lunch; ham sandwich, Nutrigrain bar, bunch of grapes. With my friends at the college.
	Risotto plus mushrooms, smoked bacon, red wine (2 glasses). Family meal (75 g).
	Staff canteen with work mates. Workday lunch- homemade soup 1/2 pt, low fat yoghurt 120 pot, bunch grapes - one handful.
	5 portions of fruit a day, everyday.
	Fruit, fruit juices when I want to snack or at break times in school.
	Last night. Meat, salad, potatoes, lentils, water. Alone.
	I use to eat salad at lunch, on my own, at the building, a pack, yesterday 2 o'clock.
	I had cereal and fruit for breakfast.
	Yesterday evening with my family. Ate grilled fish and salad, glass of water.
	At school for lunch with my friends. I had chicken breast, salad and pineapple.
	At a family occasion, dinner at the house. Drank water, vegetable dish, spinach with chapatti and lentils.
	Dinner with cousins at their home fruit + chapatti and vegetable soup.
Unhealthy	Friend's 18th birthday party. Ate lots of buffet food and drank lots.
	At an 18th birthday party. I ate buffet food such as pizza etc. I was with lots of friends. I drank some alcohol.
	Snack, home, alone, cup of tea and bar of chocolate (cooking).
	1 regular pizza, 2 glasses of fizzy lemonade on my sofa in front of the TV alone.
	A snack (occasion). Now. I just ate a chocolate biscuit & a can of Diet Coke. Ate with other PhD students.
	Chocolate Toblerone. Last night at the cinema with a group of friends 50g with friends.
	Today at Avanti, 2 slices of onion & cheese "pizza" plus new potatoes, Coca Cola & KitKat.
	School canteen with my friends had fish and chips and no drink.
	Today I ate 2 bags of crisps, 3x bar chocolate no drink for breakfast.
	About 3 days ago I missed lunch so I went to McDonalds in the afternoon, a BigMac burger and French fries, with my sister, 3:30.
	1 portion - fish and chips, a month ago, afternoon, with a friend, no occasion just for fun.
	Out on a Friday night with friends. Drank about 8 pints of beer and then went for an Indian meal about midnight.
	A night out, after club, friends, burger and chips from kebab shop.
	Last weekend. Fry up, KFC, Burger King, McDonalds and Pizza Hut.
	Lunch, McDonalds, some males, BigMac, large fries + Coca Cola.
	Breakfast, fry up - sausages, beans, egg, at Silver Grill, 6 friends.

Items posted on the Sona-Systems website for the School of Psychology's Research Participation Scheme

Study name. Eating habits performed by others (questionnaire a)

Description. Answer an online questionnaire where the only task is comparing the extent to which real descriptions of eating events are good or bad examples of different eating habits.

Online study. This study is an online survey administered by the system.

Duratio. 35 minutes

Credits. 0.6 Credits

Introductory section. This study consists of an online questionnaire, which you may now participate in. You will receive 0.4 credits immediately upon completion of the survey. You will be identified to researchers only by a unique numeric ID code. The questionnaire consists of a number of multiple- choice items. You need to complete all sections in one sitting, as the System does not allow you to resume at another time from where you left off. While you are participating, your responses will be stored in a temporary holding area as you move through the sections, but they will not be permanently saved until you complete all sections and you are given a chance to review your responses. In order to take part in research that will prove of full benefit to users of the evidence to which you are contributing, please answer each question as carefully and straightforwardly as you can.

Study questions

[Section X / 11]

1. How good is the following description as an example of the habit of "Having a low-fat food"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Having a low-fat food"? - I had boiled vegetables with fresh soup and bread for dinner at home with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Having a low-fat food"? - I had two slices of toast with raspberry jam and a glass of water for breakfast at home with my dad.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Having a low-fat food"? - I had bran flakes with nuts and skimmed-milk for breakfast at my house alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Having a low-fat food"? - I had salad, potatoes, lentils and water last night alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Having a low-fat food"? - I had salad for lunch at the building on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Having a low-fat food"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

8. How good is the following description as an example of the habit of "Having a low-fat food"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Having a low-fat drink."? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Having a low-fat drink."? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Having a low-fat drink."? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Having a low-fat drink."? - I had bran flakes with nuts and skimmed-milk for breakfast at my house alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had a low

fat vegetarian casserole meal with pulses, tofu, vegetables, and water for an evening meal with the whole family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had fish, fruit, salad, and water at a formal ball at Sudley castle with country people.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had a cheese sandwich on brown bread, one apple and one glass of water for lunch at college with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had a bowl of oat and bran porridge with a tall glass of water for breakfast at home on my own as preparation for a sport event.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had salad, potatoes, lentils and water last night alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Eating food high in fibre"? - I had salad for lunch at the building on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating food high in polyunsaturates"? - I had fish and chips and no drink at the school canteen with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating food high in polyunsaturates"? - I had fish, fruit, salad, and water at a formal ball at Sudley castle with country people.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating vegetables"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating vegetables"? - I had two bags of crisps, three bars of chocolate and no drink for breakfast today.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating vegetables"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating vegetables"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating vegetables"? - I had salad, potatoes, lentils and water last night alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating vegetables"? - I had fish and chips in the afternoon a month ago with a friend just for fun.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Eating vegetables"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

8. How good is the following description as an example of the habit of "Eating vegetables"? - I had a low fat vegetarian casserole meal with pulses, tofu, vegetables, and water for an evening meal with the whole family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

9. How good is the following description as an example of the habit of "Eating vegetables"? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating foods low in calories at main

meals"? - I had a plate of pasta and pesto, salad and fruit juice for an evening meal at home on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had a green salad starter with balsamic vinegar, chicken breast, cous cous, fresh fruit salad, a glass of white wine, and a mug of coffee for a family meal at home with my husband, son and daughter.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had bran flakes with nuts and skimmed-milk for breakfast at my house alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Eating foods low in calories at main meals"? - I had salad for lunch at the building on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a cup of tea and bar of chocolate as a snack at home alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a bowl of muesli with milk and a mug of tea for breakfast with my husband at 8:30 in the kitchen.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had soup, vegetable stir-fry, mushrooms, fruit, water and shots for a meal out last night with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a plate of pasta and pesto, salad and fruit juice for an evening meal at home on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

8. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

9. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had a regular pizza and two glasses of fizzy lemonade on my sofa in front of the TV alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

10. How good is the following description as an example of the habit of "Having drinks low in calories at main meals"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had fish and chips and no drink at the school canteen with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had boiled vegetables with fresh soup and bread for dinner at home with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had two slices of toast with raspberry jam and a glass of water for breakfast at home with my dad.

Perfect example	20% different	40% different	60% different	80% different	Totally different

8. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a plate of pasta and pesto, salad and fruit juice for an evening meal at home on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

9. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a cheese sandwich on brown bread, one apple and one glass of water for lunch at college with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

10. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a bowl of muesli with milk and a mug of tea for breakfast with my husband at 8:30 in the kitchen.

Perfect example	20% different	40% different	60% different	80% different	Totally different

11. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

12. How good is the following description as an example of the habit of "Eating small amounts of starch"? - I had salad, potatoes, lentils and water last night alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Having a food or drink labelled low-calorie or reduced-calorie"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Having a food or drink labelled low-calorie or reduced-calorie"? - I had a green salad starter with balsamic vinegar, chicken breast, cous cous, fresh fruit salad, a glass of white wine, and a mug of coffee for a family meal at home with my husband, son and daughter.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Having a food or drink labelled low-calorie or reduced-calorie"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Having a food or drink labelled low-calorie or reduced-calorie"? - I had bran flakes with nuts and skimmed-milk for breakfast at my house alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Having a food or drink labelled low-calorie or reduced-calorie"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating fresh fruit"? - I had fish, fruit, salad, and water at a formal ball at Sudley castle with country people.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating fresh fruit"? - I had a plate of pasta and pesto, salad and fruit juice for an evening meal at home on my own.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating fresh fruit"? - I had home made soup, low fat yoghurt, and a bunch grapes for lunch at a staff canteen with work mates.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating fresh fruit"? - I had two slices of toast with raspberry jam and a glass of water for breakfast at home with my dad.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 11]

1. How good is the following description as an example of the habit of "Eating salad"? - I had boiled vegetables with fresh soup and bread for dinner at home with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating salad"? - I had boiled vegetables with fresh soup and bread for dinner at home with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating salad"? - I had soup, vegetable stir-fry, mushrooms, fruit, water and shots for a meal out last night with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating salad"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating salad"? - I had a low fat vegetarian casserole meal with pulses, tofu, vegetables, and water for an evening meal with the whole family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating salad"? - I had boiled vegetables with fresh soup and bread for dinner at home with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different

Closing section. Thank you very much for taking part in this study. It is part of a research project on healthy eating and weight control. We are looking for categories of eating practices that are recognised in the culture that can be used in dietary recommendations to individual members of that population. In this questionnaire you helped us sort earlier participants' descriptions of actual eating occasions into patterns of eating and drinking previously identified in the West Midlands; your responses will help us to update the wordings for those patterns.

Study name. Eating habits performed by others (questionnaire b)

Description. Answer an online questionnaire where the only task is comparing the extent to which real descriptions of eating events are good or bad examples of different eating habits.

Online study. This study is an online survey administered by the system.

Duration. 35 minutes

Credits. 0.6 Credits

Introductory section. This study consists of an online questionnaire, which you may now participate in. You will receive 0.6 credits immediately upon completion of the survey. You will be identified to researchers only by a unique numerical ID code. The questionnaire consists of a number of multiple- choice items. You need to complete all sections in one sitting, as the System does not allow you to resume at another time from where you left off. While you are participating, your responses will be stored in a temporary holding area as you move through the sections, but they will not be permanently saved until you complete all sections and you are given a chance to review your responses.
In order to take part in research that will provide full benefit to users of the evidence to which you are contributing, please answer each question as carefully and straightforwardly as you can.

Study questions

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating snacks high in fat"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other student

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating snacks high in fat"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating snacks high in fat"? - I had two bags of crisps, three bars of chocolate and no drink for breakfast today.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating snacks high in fat"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit-Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Drinking alcohol"? - I had soup, vegetable stir-fry, mushrooms, fruit, water and shots for a meal out last night with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

2. How good is the following description as an example of the habit of "Drinking alcohol"? - I had a green salad starter with balsamic vinegar, chicken breast, cous cous, fresh fruit salad, a glass of white wine, and a mug of coffee for a family meal at home with my husband, son and daughter.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

3. How good is the following description as an example of the habit of "Drinking alcohol"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

4. How good is the following description as an example of the habit of "Drinking alcohol"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

[Section X / 9]

1. How good is the following description as an example of the habit of "Having fat in meals that could have been removed"? - I had a lot of buffet food and drink at an 18th birthday party with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

2. How good is the following description as an example of the habit of "Having fat in meals that could have been removed"? - I had fish and chips and no drink at the school canteen with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

3. How good is the following description as an example of the habit of "Having fat in meals that could have been removed"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different
○	○	○	○	○	○

4. How good is the following description as an example of the habit of "Having fat in meals that could have been removed"? - I had a regular pizza and two glasses of fizzy lemonade on my sofa in front of the TV alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating fatty meat"? - had fish and chips and no drink at the school canteen with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating fatty meat"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating fatty meat"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating fatty meat"? - I had fish, fruit, salad, and water at a formal ball at Sudley castle with country people.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating fatty meat"? - I had a green salad starter with balsamic vinegar, chicken breast, cous cous, fresh fruit salad, a glass of white wine, and a mug of coffee for a family meal at home with my husband, son and daughter.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating fatty meat"? - I had risotto with mushrooms, smoked bacon, and two glasses of red wine at a meal with the family.

Perfect example	20% different	40% different	60% different	80% different	Totally

different

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating fried foods"? - I had a regular pizza and two glasses of fizzy lemonade on my sofa in front of the TV alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating fried foods"? - I had fish and chips and no drink at the school canteen with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating fried foods"? - I had two bags of crisps, three bars of chocolate and no drink for breakfast today.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating fried foods"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had a cup of tea and bar of chocolate as a snack at home alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had a regular pizza and two glasses of fizzy lemonade on my sofa in front of the TV alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had buffet food such as pizza etc. and some alcohol at an 18th birthday party with lots of friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had buffet food such as pizza etc. and some alcohol at an 18th birthday party with lots of friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Having calories in a drink between meals"? - I had soup, vegetable stir-fry, mushrooms, fruit, water and shots for a meal out last night with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating food between meals"? - I had a cup of tea and bar of chocolate as a snack at home alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating food between meals"? - I had two bags of crisps, three bars of chocolate and no drink for breakfast today.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating food between meals"? - I had two slices of onion & cheese pizza with new potatoes, coca cola and a Kit Kat today at Avanti.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating food between meals"? - I had a Big Mac burger and french fries at McDonalds in the afternoon 3 days ago with my sister.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating food between meals"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

6. How good is the following description as an example of the habit of "Eating food between meals"? - I had a cheese sandwich on brown bread, one apple and one glass of water for lunch at college with friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

7. How good is the following description as an example of the habit of "Eating food between meals"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating a sweet extra"? - I had two bags of crisps, three bars of chocolate and no drink for breakfast today.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating a sweet extra"? - I had a cup of tea and bar of chocolate as a snack at home alone.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating a sweet extra"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating a sweet extra"? - I had two slices of toast with raspberry jam and a glass of water for breakfast at home with my dad.

Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating a sweet extra"? - I had an apple and a bottle of water for lunch yesterday with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

[Section X / 9]

1. How good is the following description as an example of the habit of "Eating a sugary food"? - I had two slices of toast with raspberry jam and a glass of water for breakfast at home with my dad.

Perfect example	20% different	40% different	60% different	80% different	Totally different

2. How good is the following description as an example of the habit of "Eating a sugary food"? - I had a chocolate biscuit and a can of diet coke as a mid-afternoon snack with other students.

Perfect example	20% different	40% different	60% different	80% different	Totally different

3. How good is the following description as an example of the habit of "Eating a sugary food"? - I had a ham sandwich, a nutrigrain bar and a bunch of grapes for lunch yesterday at college with my friends.

Perfect example	20% different	40% different	60% different	80% different	Totally different

4. How good is the following description as an example of the habit of "Eating a sugary food"? - I had a plate of pasta and pesto, salad and fruit juice for an evening meal at home on my own.

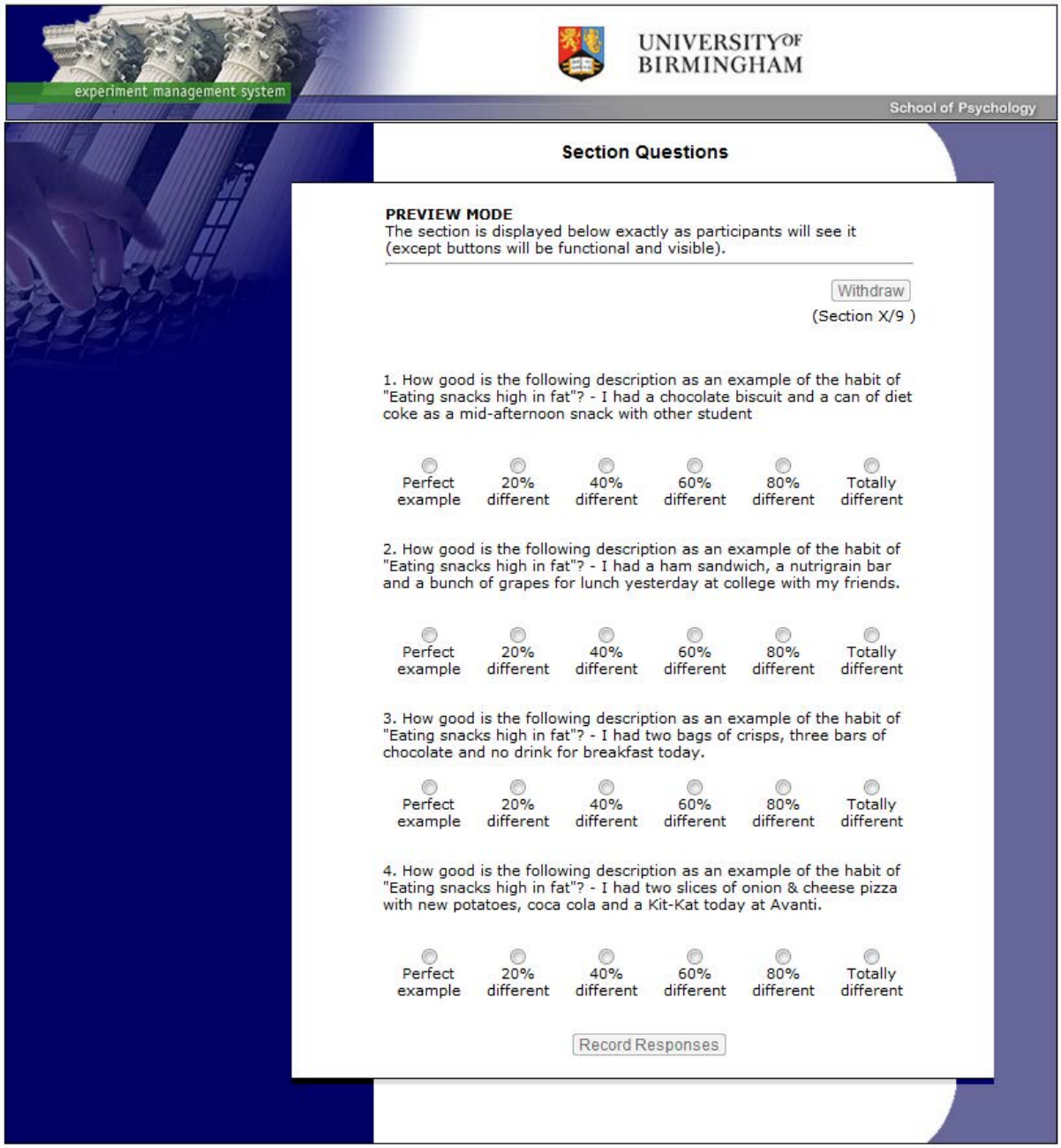
Perfect example	20% different	40% different	60% different	80% different	Totally different

5. How good is the following description as an example of the habit of "Eating a sugary food"? - I had a large typical English breakfast [hash brown, beans, toast and tea] with my sister-in-law.

Perfect example	20% different	40% different	60% different	80% different	Totally different

Closing section. Thank you very much for taking part in this study. It is part of a research project on healthy eating and weight control. We are looking for categories of eating practices that are recognised in the culture that can be used in dietary recommendations to individual members of that population. In this questionnaire you helped us sort earlier participants' descriptions of actual eating occasions into patterns of eating and drinking previously identified in the West Midlands; your responses will help us to update the wordings for those patterns.

Example of a section of the questionnaire as viewed by participants



Annexe to Chapter 5

Study name. TEST YOUR MEMORY ! (Quiz 7A)

Description. This study is based on a questionnaire that tests your ability to remember each change in what you did over a recent period. The questionnaire provides you with both open-ended & multiple-choice closed answers. You may ask for a report on the findings if you wish to provide me with your email address.

Online study. This study is an online survey administered by the system.

Prescreen restrictions. No Restrictions

Duration. 18 minutes

Credits. 0.3 Credits

Introductory section. This questionnaire asks you to give a specific name to the first thing you spent some time doing after you got up yesterday and when you finished that activity and started the next one. The test of your memory is whether you forget what you did next. Please keep your answers anonymous. You will be identified to the research team only by a unique numerical ID code. You are given a chance to review your responses and alter them if you wish after you have finished answering the questions. After you have told the system to save your temporarily held answers in permanent form, you will receive 0.3 credits.
Thank you very much for taking part in this study. We are looking for the wordings used to refer to common daily activities. The phrases collected will be used in follow-up studies to generate a small number of types of activity that are readily identified. These descriptions can be used in research on daily habits that avoids bias in investigators' terminology. If you would like to see the findings from this questionnaire, please email the researcher on AXL699@Bham.ac.UK and I shall email you a short report in a few weeks' time.

Study questions. Please name below each of your activities that takes an appreciable time, in a way that differentiates it from your other activities. If you were doing more than one thing at the same time, please name each activity in your answer. To help you remember, you are also asked where you were and if anyone was with you. The questions are identical for each activity from the first you name and so do not worry if a query is a bit odd for a particular activity. Our interest is mainly in your naming of each thing you do, and the time spent on it.

1. What did you do immediately after getting up yesterday?

2. Where were you while you did that?

3. Were you doing it with anyone else?

○	○	○
No	With one other person	With two or more others

4. When did you stop doing that?

5. Please name specifically what you did next.

6. Where did you do that? If this was a change in place, please name how you got there from the previous place.

7. Were you doing it with anyone else?

○	○	○

No With one other person With two or more others

8. When did you stop doing that?

9. Please name specifically what you did next

10. Where did you do that? If this was a change in place, please name how you got there from the previous place

11. Were you doing it with anyone else?

No With one other person With two or more others

12. When did you stop doing that?

13. Please name specifically what you did next

14. Where did you do that? If this was a change in place, please name how you got there from the previous place

15. Were you doing it with anyone else?

No With one other person With two or more others

16. When did you stop doing that?

17. Please name specifically what you did next

18. Where did you do that? If this was a change in place, please name how you got there from the previous place

19. Were you doing it with anyone else?

No With one other person With two or more others

20. When did you stop doing that?

21. Please name specifically what you did next

22. Where did you do that? If this was a change in place, please name how you got there from the previous place

23. Were you doing it with anyone else?

No With one other person With two or more others

24. When did you stop doing that?

25. Please name specifically what you did next

26. Where did you do that? If this was a change in place, please name how you got there from the previous place

27. Were you doing it with anyone else?

No | With one other person | With two or more others

28. When did you stop doing that?

29. Please name specifically what you did next

30. Where did you do that? If this was a change in place, please name how you got there from the previous place

31. Were you doing it with anyone else?

No | With one other person | With two or more others

32. When did you stop doing that?

33. Please name specifically what you did next

34. Where did you do that? If this was a change in place, please name how you got there from the previous place

35. Were you doing it with anyone else?

No | With one other person | With two or more others

36. When did you stop doing that?

37. Please name specifically what you did next

38. Where did you do that? If this was a change in place, please name how you got there from the previous place

39. Were you doing it with anyone else?

No | With one other person | With two or more others

40. When did you stop doing that?

41. Please name specifically what you did next

42. Where did you do that? If this was a change in place, please name how you got there from the previous place

43. Were you doing it with anyone else?

No | With one other person | With two or more others

44. When did you stop doing that?

45. Please name specifically what you did next

46. Where did you do that? If this was a change in place, please name how you got there from the previous place

47. Were you doing it with anyone else?

No | With one other person | With two or more others

48. When did you stop doing that?

49. Please name specifically what you did next

50. Where did you do that? If this was a change in place, please name how you got there from the previous place

51. Were you doing it with anyone else?

No | With one other person | With two or more others

52. When did you stop doing that?

53. Please name specifically what you did next

54. Where did you do that? If this was a change in place, please name how you got there from the previous place

55. Were you doing it with anyone else?

No | With one other person | With two or more others

56. When did you stop doing that?

57. Please name specifically what you did next

58. Where did you do that? If this was a change in place, please name how you got there from the previous place

59. Were you doing it with anyone else?

No | With one other person | With two or more others

60. When did you stop doing that?

61. Please name specifically what you did next

62. Where did you do that? If this was a change in place, please name how you got there from the previous place

63. Were you doing it with anyone else?

No | With one other person | With two or more others

64. When did you stop doing that?

65. Please name specifically what you did next

66. Where did you do that? If this was a change in place, please name how you got there from the previous place

67. Were you doing it with anyone else?

No	With one other person	With two or more others

68. When did you stop doing that?

69. Please name specifically what you did next

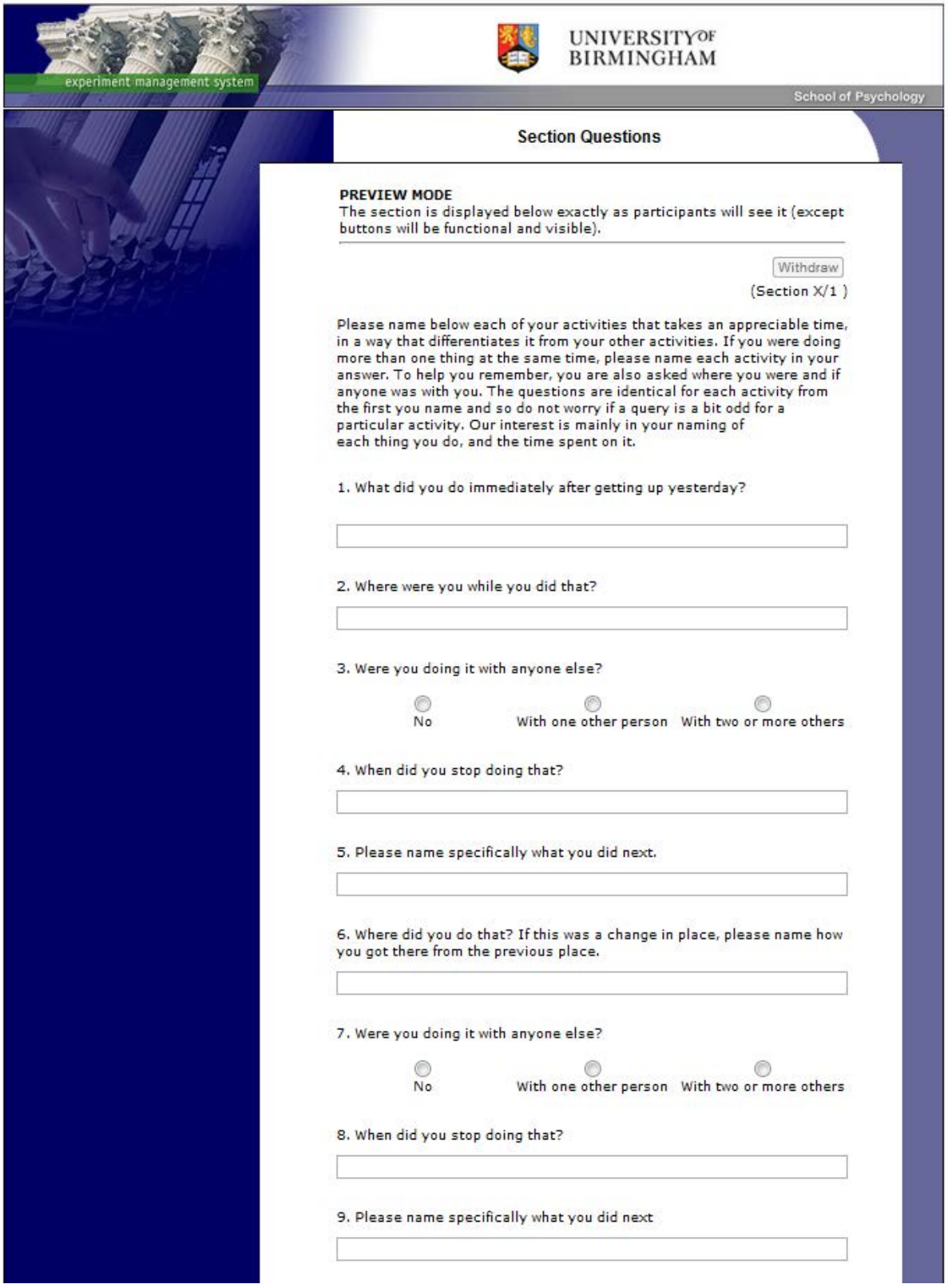
70. Where did you do that? If this was a change in place, please name how you got there from the previous place

71. Were you doing it with anyone else?

No	With one other person	With two or more others

72. When did you stop doing that?

Example of a part of the questionnaire as viewed by participants



Annexe to Chapter 8

First questionnaire**: recruitment and informed consent** (on RPS)

Study's name. *Memories of eating and movement*

Description. *You are asked to recall recent occasions when you ate or moved around. After sampling this task, you can extend your participation to 8 weeks of completing the same questionnaire once a week.*

Restrictions. *For subsequent weekly questionnaires, you will need access to scales for weighing yourself before logging on to the study on the RPS website.*

Credits. *0.5 credits*

Introductory section. This study is a sample of the questionnaire you'd complete each week if you agreed to take further part at the end of this session.

Study questions

[Section 1]

For each sort of eating or moving I ask you about below, please think first where you were the last time you did it and then try to remember the time and date of that occasion. You can use a calendar (e.g. your mobile) to help you find the date.

1. Please think where you were the last time you ate vegetables or salad in a meal. Please give in the box below the time on the clock and date of that occasion in the following format HR:MN xm, DY MTH YR, e.g. 12:30 pm, 27 Nov 08 or 08:40 am, 09 Jan 09.

2. Now think where you were on the occasion before that when you ate vegetables or salad in a meal. Please write the time and date in the box below.

[Section 2 – respondent can't see past Sections]

3. Please think where you were the last time you ate fish or meat with little or not fat you could see, e.g. tuna, prawns, chicken, lamb, beef. Please give in the box below the time on the clock and date of that occasion in the following format HR:MN xm, DY MTH YR, e.g. 10:15 am, 27 Nov 08.

4. When was the occasion before that when you ate fish or meat with little or not fat you could see?

[Section 3]

5. When did you last eat fruit within a meal?

6. When was the occasion before that?

[Section 4]

7. When did you last cut down on fat in a meal?

8. When was the occasion before that?

[Section 5]

9. When did you last have bread at the start of a meal which was several hours after the previous meal?

10. Can you think of where you had done that before? If so, when was that?

[Section 6]
In the following cases of eating or drinking between meals, please also state the timings of the meal before and the meal after the remembered occasion.

11. When did you last have some calories between meals in a food or drink, e.g. chocolate bar, biscuits, crisps, fruit juice, coke? Please continue to state times and dates in the format HR:MN xm, DY MTH YR.

12. What was the time of the last meal you ate before this occasion?

13. What time was the meal you had after those calories?

14. When was the occasion before that when you had some calories between meals?

15. What was the time of your meal before this occasion?

16. What time was the meal you had after those calories?

[Section 7]
17. When did you last have some item of fruit or salad between meals when you wanted something to eat, e.g. apple, grapes, carrot, tomato? Please continue to state times and dates in the format HR:MN xm, DY MTH YR.

18. What was the time of the meal you had before this occasion?

19. What time was the meal you ate after this occasion?

20. When last before that did you have some fruit or salad item between meals when you wanted something to eat?

21. What was the time of your meal before this occasion?

22. What time was your meal after this occasion?

[Section 8]
23. When did you last drink some alcohol away from a meal?

24. Please describe what you drank on that occasion

25. What was the time of the meal you ate before this occasion?

26. What time was the meal you had after this occasion?

27. When was the occasion before that when you drank some alcohol between meals?

28. Please describe what you drank on that occasion

29. What was the time of the meal you ate before this occasion?

30. What time was the meal you had after this occasion?

[Section 9]
31. When did you last walk outdoors?

32. How many minutes' walk was that?

33. When was the occasion before that?

34. How many minutes' walk was that?

[Section 10]

35. When did you last cycle for more than 15 minutes?

36. When was the occasion before that?

[Section 11]

37. When did you last use stairs rather than lift or escalators?

38. Please state how many floors were and whether up or down

39. When was the occasion before that?
40. Please state how many floors were and whether up or down

[Section 12]

41. When did you last do more than about 30 minutes of vigorous exercise, e.g. jog, swim, fitness class, workout at the gym?

42. When was the occasion before that?

[Section 13]

43. Please write in below your weight when you last weighed yourself.

[Section 14]

Thank you for completing this questionnaire. Please consider answering the above questions weekly. When you have completed 8 reports at weekly intervals of no fewer than 6 days, you will be granted 4 participation credits plus 0.5 credits per additional weekly questionnaire thereafter. You will be using your memory to help us find out which patterns of eating or movement do most to help people keep healthy. You'll need to weigh yourself at the same time of day before starting the report each week. From week 3 you will be asked to do one of these activities more or less often: it will be a healthy option that is feasible for you, according to our calculation from your reports. We need your email address in order to send you this tailored request and to remind you when the next weekly report is due. Your answers will be kept confidential and only I will know your email address.

44. Would you like to take part in the 8-week study and continue for any further week(s) to the end of Spring Term?

• Yes, I would • No, I wouldn't • Maybe *RPS set to allow one option only*

45. If you have agreed to participate or wish to receive any additional information, please provide me with an email address for contacting you.

Closing section. Thank you for completing this Sample Report. If you have agreed to join the study please wait at least 6 days before making your first weekly report. If you have given me your email address, I shall send you information within a few days about access to the Report 1 posted on the RPS website.

Second questionnaire**: Repeated questionnaire** (on RPS)

Study name. *Memories of eating and movement - Report 1*

Description (Report 1). This study uses weekly repetitions of a questionnaire to test your autobiographical memory for timings of episodes when you engaged in particular sorts of eating or movement. A good performance by you in retrieving these episodes will help us identify activities that contribute to wellbeing. Please wait at least six days after completing the Sample Report before you start this Report 1. You will be granted 4 credits after you have done 8 weeks and then 0.5 credits per week bunched together to the end of Spring Term. Ideally, each report should be in the same day of the week after you weigh yourself. Take your weight readings each week at the same time of day, preferably after getting up and before your usual meal, having relieved yourself and wearing at most light clothing with no shoes.

Description (Report 2-8). This study uses weekly repetitions of a questionnaire to test your autobiographical memory for timings of episodes when you engaged in particular sorts of eating or movement. A good performance by you in retrieving these episodes will help us identify activities that contribute to wellbeing. Please wait at least six days after completing the Report 1 before you start this Report 2. You will be granted 4 credits after you have done 8 weeks and then 0.5 credits per week bunched together to the end of Spring Term.

Eligibility requirements. *Access to scales for weighing yourself.*

Credits. *4 credits*

Preparation. Before you start the Report you should weigh yourself.

Introductory section. *Please log in if you are ready to make your first report.*

Study questions

[Section 1]

1. Please provide the reading on the scales of your weight today, either in pounds/stones or in kilograms including fractions.

2. What time did you read your weight?

[Section 2]

For each sort of eating or moving I ask you about below, please think first where you were the last time you did it and then try to remember the time and date of that occasion. You can use a calendar (e.g. your mobile) to help you find the date.

3. Please think where you were the last time you ate vegetables or salad in a meal. Please give in the box below the time on the clock and date of that occasion in the following format HR:MN xm, DY MTH YR, e.g. 12:30 pm, 27 Nov 08 or 08:40 am, 09 Jan 09.

4. Where were you on the occasion before that when you ate vegetables or salad in a meal? Please write the time and date in the box below.

[Section 3 – respondent can't see past Sections]

5. Please think where you were the last time you ate fish or meat with little or not fat you could see, e.g. tuna, prawns, chicken, lamb, beef. Please give in the box below the time on the clock and date of that occasion in the following format HR:MN xm, DY MTH YR, e.g. 10:15 am, 27 Nov 08.

6. When was the occasion before that when you ate fish or meat with little or not fat you could see?

[Section 4]

7. When did you last eat fruit within a meal?

8. When was the occasion before that?

[Section 5]

9. When did you last cut down on fat in a meal?

10. When was the occasion before that?

[Section 6]

11. When did you last have bread at the start of a meal which was several hours after the previous meal?

12. Can you think of where you had done that before? If so, when was that? [Box]

[Section 7]

In the following cases of eating or drinking between meals, please also state the timings of the meal before and the meal after the remembered occasion.

13. When did you last have some calories between meals in a food or drink, e.g. chocolate bar, biscuits, crisps, fruit juice, coke? Please continue to state times and dates in the format HR:MN xm, DY MTH YR.

14. What was the time of the last meal you ate before this occasion? [Box]

15. What time was the meal you had after those calories?

16. When was the occasion before that when you had some calories between meals?

17. What was the time of your meal before this occasion?

18. What time was the meal you had after those calories?

[Section 8]

19. When did you last have some item of fruit or salad between meals when you wanted something to eat, e.g. apple, grapes, carrot, tomato? Please continue to state times and dates in the format HR:MN xm, DY MTH YR.

20. What was the time of the meal you had before this occasion?

21. What time was the meal you ate after this occasion?

22. When last before that did you have some fruit or salad item between meals when you wanted something to eat?

23. What was the time of your meal before this occasion?

24. What time was your meal after this occasion?

[Section 9]

25. When did you last drink some alcohol away from a meal?

26. Please describe what you drank on that occasion?

27. What was the time of the meal you ate before this occasion?

28. What time was the meal you had after this occasion?

29. When was the occasion before that when you drank some alcohol between meals?

30. Please describe what you drank on that occasion?

31. What was the time of the meal you ate before this occasion?

32. What time was the meal you had after this occasion?

[Section 10]

33. When did you last walk outdoors?

34. How many minutes' walk was that

35. When was the occasion before that?

36. How many minutes' walk was that

[Section 11]

37. When did you last cycle for more than 15 minutes?

38. When was the occasion before that?

[Section 12]

39. When did you last use stairs rather than lift or escalators?

40. Please state how many floors were and whether up or down?

41. When was the occasion before that?

42. Please state how many floors were and whether up or down?

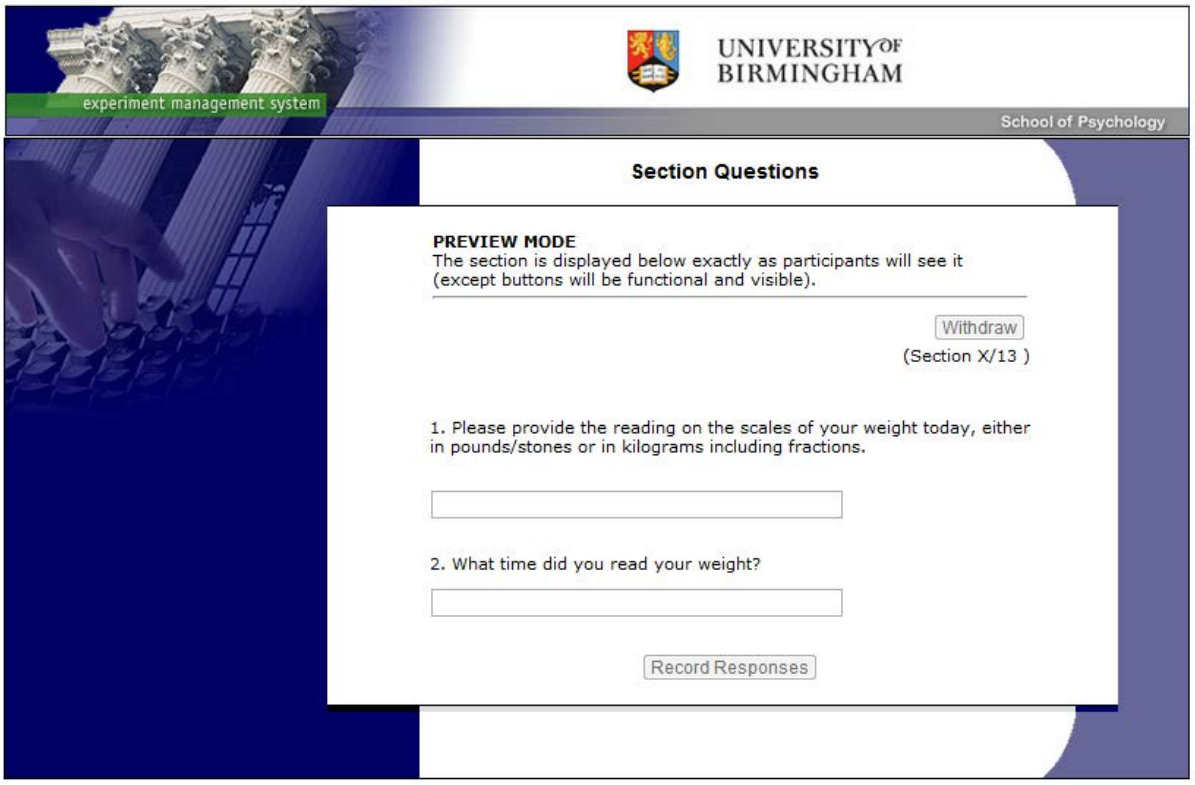
[Section 13]

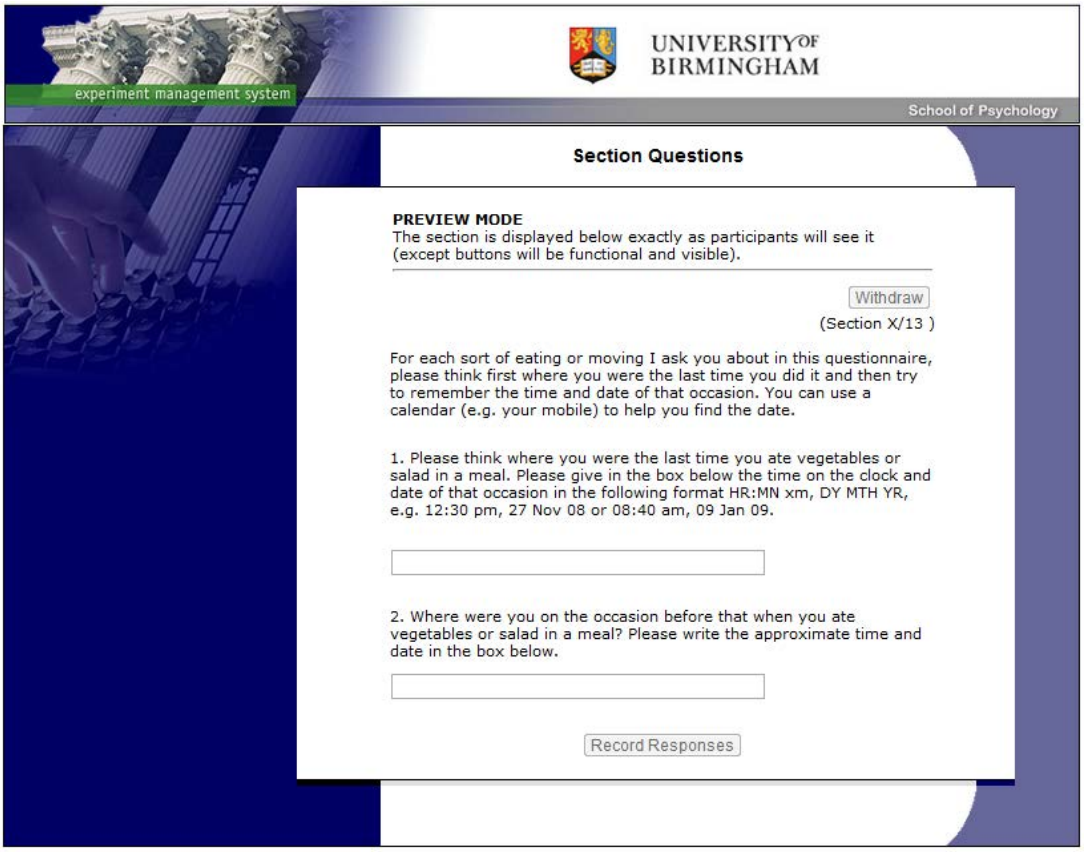
43. When did you last do more than about 30 minutes of vigorous exercise, e.g. jog, swim, fitness class, workout at the gym?

44. When was the occasion before that?

Closing text. Thank you for making your report this week. You will receive a reminder email one or two days before your next report is due.

Examples of sections of questionnaire as viewed by participants





Welcome email

To: Participant
From: Researcher
Subject: Memories of eating and movement - Welcome

Many thanks for agreeing to take part in this study. I'll send you an email 5 days after you volunteered to remind you to do Report 1. Please select a day of the week that you can maintain throughout the Spring Term on which you will make your report each week.

If you miss the usual day, or a whole week, please make the next report as soon as you can. Then please get back to the (same or another) fixed day each week. Your reports, however, will contribute more precise evidence if they are exactly at weekly intervals.

We need to standardise the way in which time and date are reported. Please use the format that is in my database (Excel). This is:

HR:MN xm, DY MTH YR

e.g. 08:30 pm, 27 Nov 08 or 11:50 am, 09 Jan 09

In particular put a colon between the hour and the minutes and make space between the time and the am or pm.

Please weigh yourself before making your report. To provide the best data, you should take the weight readings each week at the same time of day, preferably after getting up and before your usual meal, having relieved yourself and wearing at most light clothing with no shoes.

Please feel free to contact me if you have any query.

Antonio Laguna-Camacho
PhD student
School of Psychology, University of Birmingham

Reminder email

To: Participant
From: Researcher
Subject: Memories of eating and movement– Report week [number of report]

This is a reminder to report your newly read weight and recent eating and exercise this week. Please use the questionnaire titled 'Memories of eating and movement - Report [number of report]' on the RPS website, http://birmingham.sona-systems.com

Many thanks for taking part in my research.

Antonio Laguna-Camacho
PhD student
School of Psychology, University of Birmingham

Email request for change frequency of a habit

To: Participant
From: Researcher
Subject: Memory of recent eating episodes – request

Thank you for completing the latest weekly questionnaire. In order for me to get the best evidence out of your and other's memories, it would be most helpful if you would change one of the reported activities, while not changing others at the same time.

Looking at your and others' frequencies of all the activities, it seems to me that it would be feasible for you to [– habit description here –] less / more often. This change should do no harm and might be of benefit to you if you kept it up.

Please let me know as soon as you can if you do not want to make this change. In that case, please let me know if you could consider another change after I have selected another one to put to you.

Antonio Laguna-Camacho
PhD student
School of Psychology, University of Birmingham

Annexe to Chapter 9

Recruiting session on the Research Participation Scheme (Sona System) website

Study's name. Experiment on yourself (up to 3 credits each Term)

Description. This experiment uses weekly repetitions of a questionnaire to measure any change in weight while you do less or more of a pattern of eating, drinking or moving about, when you keep the rest of your activities and eating the same as usual. Your recent memories of eating and exercise can be combined with reports from others to work out which changes affect weight most. You will be given 1.5 participation credits for each set of five consecutive weekly reports.

Credits. 0 credits / 5 credits

Eligibility. Have access to scales for weighing yourself.

Preparation. Before you start the Report you should weigh yourself.

Introductory section. This questionnaire gives you a sample of what your memories would contribute to a controlled experiment that measures the effects of common activities on body weight. You would be providing novel evidence that could be used to show people like you what works in weight control. You do not need to have a personal interest in changing weight in order to work with in gathering this evidence. We will only ask you to make modest changes in your habits that should at the most change your weight only slightly while you persist in that change.

Study questions

[Section 1]
1. Please state below your height in metres (e.g. 1.72) or feet and inches.

2. Please write in below your weight when you last weighed yourself, either in kilograms including fractions or in stones and pounds (or just pounds).

[Section 2]
To help you recall accurately the latest 2 occasions you did each sort of eating and exercise described below, please think about where you were and any people present, and then try to remember the time of day and day of the week of that event. (You may need to look at a calendar to be sure of the date in the month.) We need to standardise the way in which time and date are reported. Please provide the responses in the format that is in the Excel database of your responses. This is: Hour{colon}Min{space}am/pm{space}DayMonthYear, e.g. 1:30 pm 23Sep09 or 00:20 am 28Sep09. Answering, for example, 14:00 pm 2Oct09 is not correct, the correct format would be 2:00 pm 2Oct09 or if you prefer using the 24-hour clock, it would be 14:00 2Oct09.

1. When did you last eat something at breakfasttime? - for example, cereal or toast.

2. When was the last occasion before that?

[Section 3]
1. When did you last walk fast from one place to another? In the box below, please write the time on the clock as best you can recall and the date of that occasion, in the format
Hour{colon}Min{space}am/pm{space}DayMonthYear, e.g. 9:10 am 28Sep09

[Section 4]
1. When did you last walk both up and down stairs when a lift or escalator was available?

2. When was the occasion before that?

[Section 5]
1. When did you last have a drink with calories in it between meals? - for example, apple juice, Coca cola, beer, vodka, coffee with cream and/or sugar.

2. When was the occasion before that?

[Section 6]
1. When did you last have a drink with calories in it as part of a meal or shortly before the meal?

2. When was the occasion before that?

[Section 7]

1. When did you last eat bread at the start of a meal which was several hours after the previous meal?

2. When was the occasion before that?

[Section 8]
1. When did you last eat something at lunchtime?

2. When was the occasion before that?

[Section 9]
1. When did you last eat bread in a meal after other foods?

2. When was the occasion before that?

[Section 10]
1. When did you last have a meal based on fat-rich food? - for example, cheese, sausages, streaky bacon, fried bread, lots of fatty spread or oil.

2. When was the occasion before that?

[Section 11]
1. When did you last do some housework? – for example, hoover the house, clean the bathroom

2. When was the occasion before that?

[Section 12]
1. When did you last spend some time moving around when you might have been sitting down? Please continue giving times and dates in the format: hour:min {space} am/pm {space} DayMonthYear

2. When was the occasion before that?

[Section 13]
1. When did you last have one or more snackfoods between meals? - for example, crisps, sweets, chocolate bar, cake, biscuits.

2. When was the occasion before that?

[Section 14]
1. When did you last have one or more snackfoods as part of a full meal or slightly before a meal?

2. When was the occasion before that?

[Section 15]
1. When did you last eat twice or more between the late afternoon and going to bed? It might have been tea and supper, or dinner and a nightcap.

2. When was the occasion before that?

[Section 16]
1. When did you last eat just once between late afternoon and bedtime?

2. When was the occasion before that?

[Section 17]
1. When did you last add salt to your food or choose some salty product such as salted crisps, peanuts or 'lassi' drink?

2. When was the occasion before that?

[Section 18]
1. When did you last have non-fatty high-protein food in a meal? - for example, egg, low-fat cheese, skinless chicken, fish (not deep-fried), prawns, meat without any fat you could see.

2. When was the occasion before that?

[Section 19]
1. When did you last have a meal that was low in fat and had very little protein? - for example, pasta topped with tomato sauce, a salad, baked potato, bread and Marmite or jam, a dish based on vegetables only, toast with marmalade only.

2. When was the occasion before that?

[Section 20]
1. When did you last do something really energetic? E.g., jog, gym, fitness class, swim, sport.

2. When was the occasion before that?

[Section 21]
This experiment needs volunteers to fill in that questionnaire once a week while in Birmingham, continuing for as much of this academic year as possible. You would be randomly assigned to change at least one eating or exercise habit each Term, maybe two of them. You'd need access to the same weighing scale to take a reading of your weight at the same time of day on the day each week that you report your memories. You will be given 1.5 participation credits for each set of five reports you complete over at least 5 weeks. If you can continue right through to summer exams in the weeks you are in Birmingham that would provide the best evidence but even ten reports would be useful. Your answers will be kept confidential and I will know only your email address.

1. Would you like to take part in the experiment?

Yes, I would.	No, I wouldn't.	Maybe.

2. If you have agreed to participate, please provide me with an email address for sending you a reminder before each report is due and also each request to do more or less of the type of eating or exercise assigned to you for change at that stage.

Closing section. Many thanks for helping in this research so far. If you have agreed to join the experiment, please wait at least 6 days before completing your first report of your memories on the RPS website in the survey with the title 'Experiment using memories of eating and exercise - Report 1'. If you have given me your email address, I shall send you a reminder within a few days. Please select a day of the week that you can maintain throughout Term-time on which you will report your memories and weight each week. If you miss the usual day, or a whole week, please make the next report as soon as you can. Then please get back to the (same or another) fixed day each week. Your reports will contribute more precise evidence if they are exactly at weekly intervals. Please weigh yourself before making your report. To provide the best data, you should take the weight readings each week at the same time of day, preferably after getting up and before your usual meal, having relieved yourself and wearing at most light clothing with no shoes.

Information for Reports presented to participants on the RPS

Study name. Experiment using memories of eating and exercise – Report [number report]

Description. This experiment uses weekly repetitions of a questionnaire to measure any change in weight while you do less or more of a pattern of eating, drinking or moving about, when you keep the rest of your activities and eating the same as usual. Your recent memories of eating and exercise can be combined with reports from others to work out which changes affect weight most. You will be given 1.5 participation credits for each set of five consecutive weekly reports.

Credits. 0 credits / 5 credits

Eligibility. Have access to scales for weighing yourself.

Preparation. Before you start the Report you should weigh yourself.

Introductory section. Please sign into this study if you are doing Report 1 after taking the reading of your today's weight.

Study questions
[Section 1]
1. Please provide the reading on the scales of your weight today, either in kilograms including fractions or in stones and pounds (or just pounds).

2. What time did you read your weight?

[Section 2]
To help you recall accurately the latest 2 occasions you did each sort of eating and exercise described below, please think about where you were and any people present, and then try to remember the time of day and day of the week of that event. (You may need to look at a calendar to be sure of the date in the month.) We need to standardise the way in which time and date are reported. Please provide the responses in the format that is in the Excel database of your responses. This is: Hour{colon}Min{space}am/pm{space}DayMonthYear, e.g. 1:30 pm 23Sep09 or 00:20 am 28Sep09. Answering, for example, 14:00 pm 2Oct09 is not correct, the correct format would be 2:00 pm 2Oct09 or if you prefer using the 24-hour clock, it would be 14:00 2Oct09.

1. When did you last eat something at breakfasttime? - for example, cereal or toast.

2. When was the occasion before that?

[Section 3]
1. When did you last walk fast from one place to another? In the box below, please write the time on the clock as best you can recall and the date of that occasion, in the format Hour{colon}Min{space}am/pm{space}DayMonthYear, e.g. 9:10 am 28Sep09

2. When was the occasion before that?

[Section 4]
1. When did you last walk both up and down stairs when a lift or escalator was available?

2. When was the occasion before that?

[Section 5]
1. When did you last have a drink with calories in it between meals? - for example, apple juice, Coca cola, beer, vodka, coffee with cream and/or sugar.

2. When was the occasion before that?

[Section 6]
1. When did you last have a drink with calories in it as part of a meal or shortly before the meal?

2. When was the occasion before that?

[Section 7]
1. When did you last eat bread at the start of a meal which was several hours after the previous meal?

2. When was the occasion before that?

[Section 8]
1. When did you last eat something at lunchtime?

2. When was the occasion before that?

[Section 9]
1. When did you last eat bread in a meal after other foods?

2. When was the occasion before that?

[Section 10]
1. When did you last have a meal based on fat-rich food? - for example, cheese, sausages, streaky bacon, fried bread, lots of fatty spread or oil.

2. When was the occasion before that?

[Section 11]
1. When did you last do some housework? – for example, hoover the house, clean the bathroom

2. When was the occasion before that?

[Section 12]
1. When did you last spend some time moving around when you might have been sitting down? Please continue giving times and dates in the format: hour:min {space} am/pm {space} DayMonthYear

2. When was the occasion before that?

[Section 13]
1. When did you last have one or more snackfoods between meals? - for example, crisps, sweets, chocolate bar, cake, biscuits.

2. When was the occasion before that?

[Section 14]
1. When did you last have one or more snackfoods as part of a full meal or slightly before a meal?

2. When was the occasion before that?

[Section 15]
1. When did you last eat twice or more between the late afternoon and going to bed? It might have been tea and supper, or dinner and a nightcap.

2. When was the occasion before that?

[Section 16]
1. When did you last eat just once between late afternoon and bedtime?

2. When was the occasion before that?

[Section 17]
1. When did you last add salt to your food or choose some salty product such as salted crisps, peanuts or 'lassi' drink?

2. When was the occasion before that?

[Section 18]
1. When did you last have non-fatty high-protein food in a meal? - for example, egg, low-fat cheese, skinless chicken, fish (not deep-fried), prawns, meat without any fat you could see.

2. When was the occasion before that?

[Section 19]
1. When did you last have a meal that was low in fat and had very little protein? - for example, pasta topped with tomato sauce, a salad, baked potato, bread and Marmite or jam, a dish based on vegetables only, toast with marmalade only.

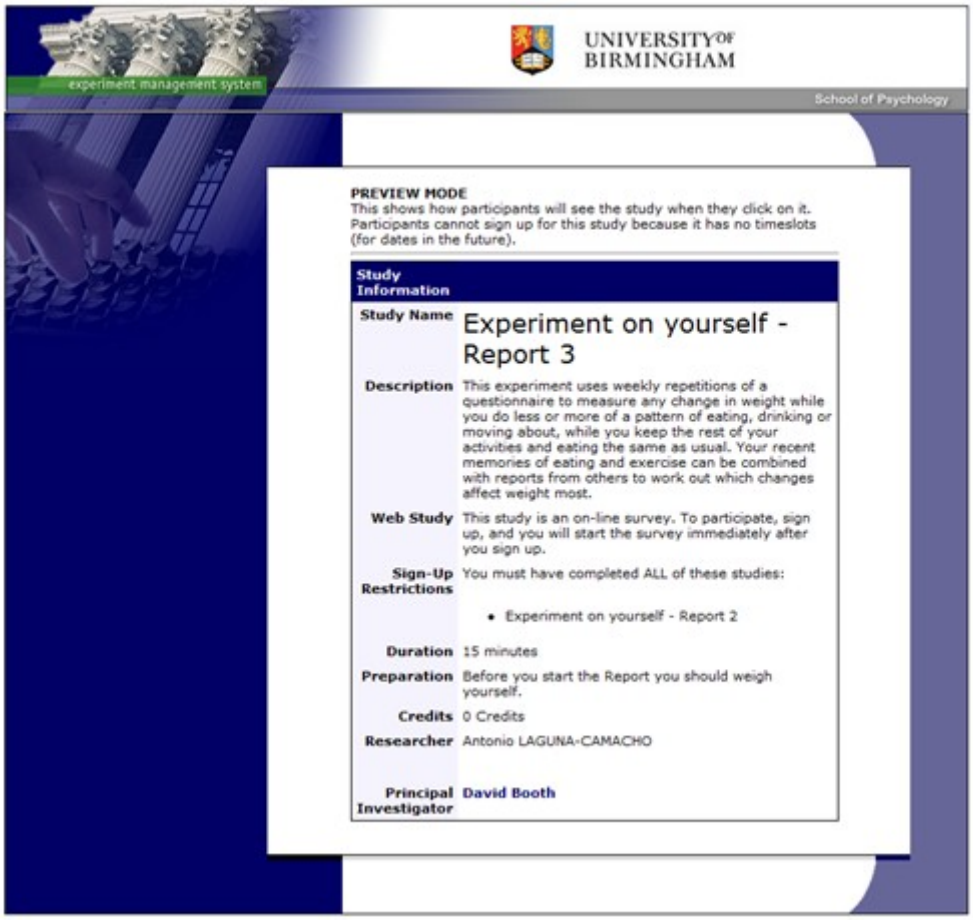
2. When was the occasion before that?

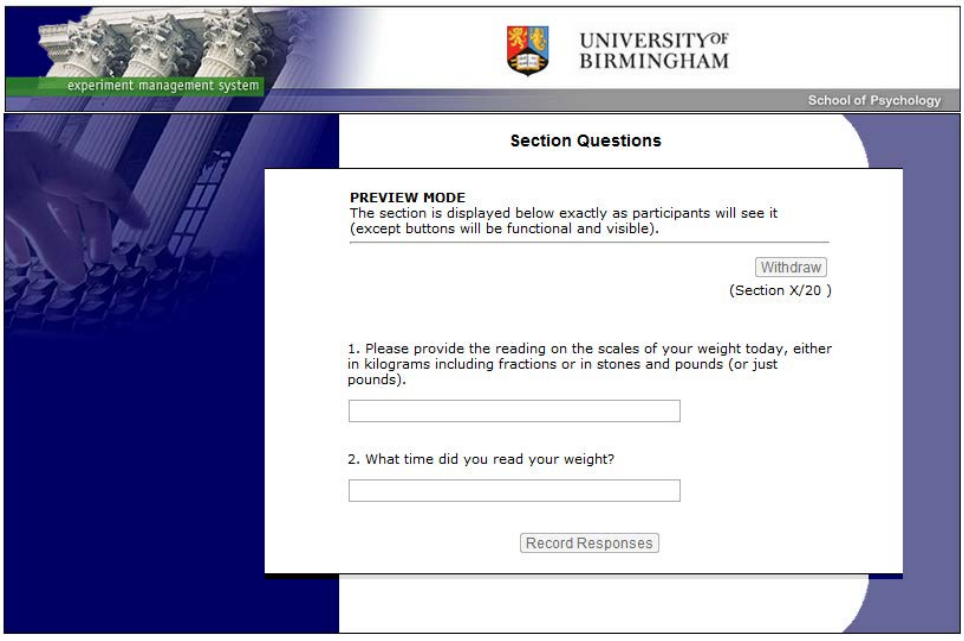
[Section 20]
1. When did you last do something really energetic? E.g., jog, gym, fitness class, swim, sport.

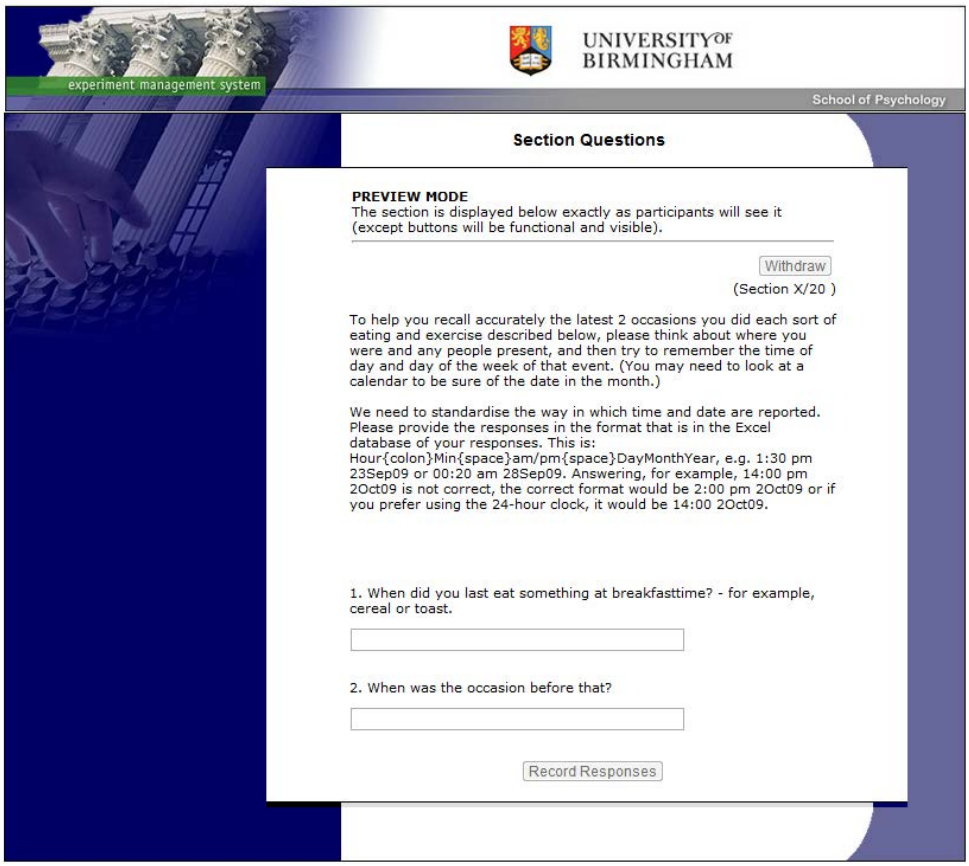
2. When was the occasion before that?

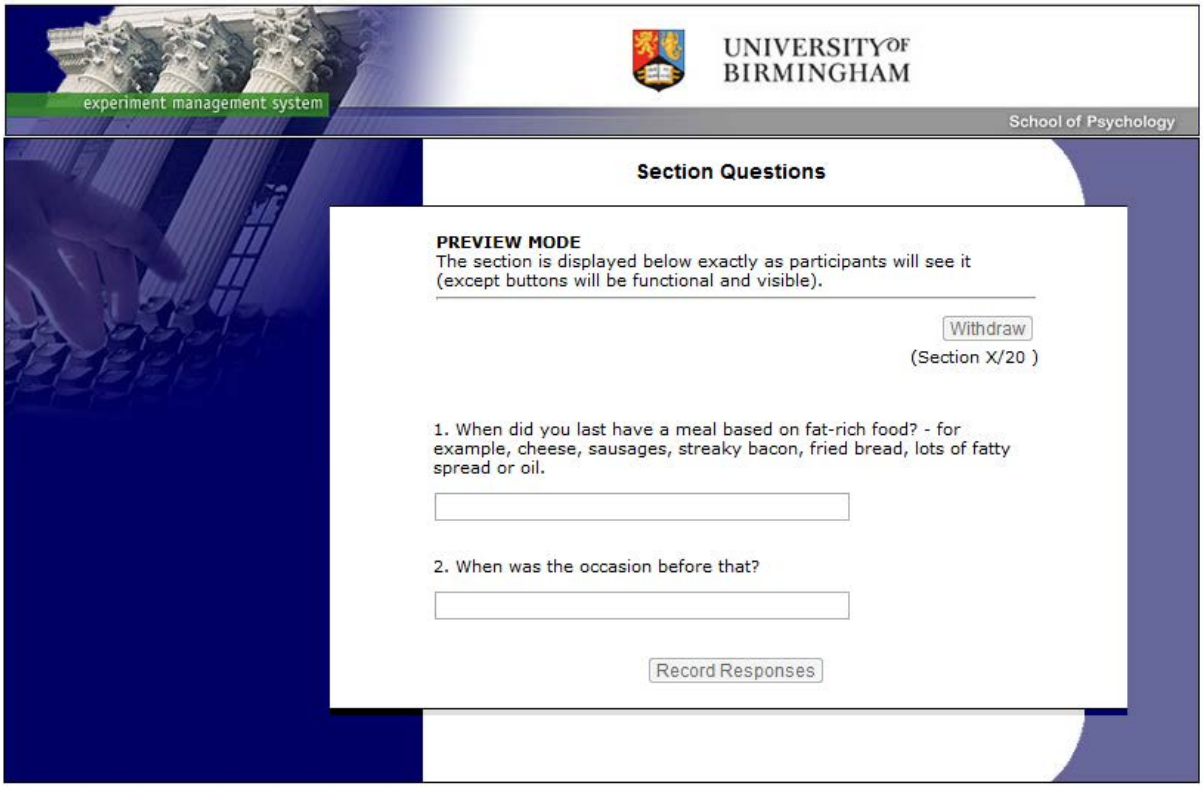
Closing section. Many thanks for doing your weekly report of weight and memories of eating and exercise. I will send you a reminder one or two days before your next report is due.

Examples of sections of the questionnaire as viewed by participants






experiment management system
UNIVERSITY OF BIRMINGHAM
School of Psychology
Section Questions
PREVIEW MODE
The section is displayed below exactly as participants will see it (except buttons will be functional and visible).
Withdraw
(Section X/20)
To help you recall accurately the latest 2 occasions you did each sort of eating and exercise described below, please think about where you were and any people present, and then try to remember the time of day and day of the week of that event. (You may need to look at a calendar to be sure of the date in the month.)
We need to standardise the way in which time and date are reported. Please provide the responses in the format that is in the Excel database of your responses. This is: Hour{colon}Min{space}am/pm{space}DayMonthYear, e.g. 1:30 pm 23Sep09 or 00:20 am 28Sep09. Answering, for example, 14:00 pm 2Oct09 is not correct, the correct format would be 2:00 pm 2Oct09 or if you prefer using the 24-hour clock, it would be 14:00 2Oct09.
1. When did you last eat something at breakfasttime? - for example, cereal or toast.
2. When was the occasion before that?
Record Responses


experiment management system
UNIVERSITY OF BIRMINGHAM
School of Psychology
Section Questions
PREVIEW MODE
The section is displayed below exactly as participants will see it (except buttons will be functional and visible).
Withdraw
(Section X/20)
1. When did you last have a meal based on fat-rich food? - for example, cheese, sausages, streaky bacon, fried bread, lots of fatty spread or oil.
2. When was the occasion before that?
Record Responses

Welcome email

To: participants
From: researcher
Subject: Welcome to memories of eating and exercise

Dear Participant,

Thank you for agreeing to take part in this experiment. Your memories of recent occasions of eating and exercise will contribute to evidence on how change in the frequency of each habit affects weight.

This research is part of a long-term programme to validate personally useful advice for those who wish to control their weight. Small changes within the healthy weight range are just as good evidence as weight reduction in overweight people. What matters is that people recognise what activities are being described. So please let me know if you are at all unclear about any item in the questionnaire.

The experimental design is for you to be asked to change in a healthy direction how often you carry out a randomly assigned activity reported in the questionnaire while you keep the rest of your patterns of eating and moving around the same as usual. It would provide the best evidence if you continued to contribute weekly reports right through to summer exams in the weeks you are in Birmingham, but ten reports in one Term would be useful.

I'll send you an email when you are due to change a particular habit. You might test two habits in a whole Term's participation. How much change you make is your choice. The most important thing is that you keep up for the rest of Term at least whatever change you do make in response to my request.

To get started, just wait 5 to 7 days from the sample questionnaire and then select the day of the week you will do your reports each week. I shall send you a reminder before that report is due and before each subsequent report.

Many thanks again for working with us on this research.

Antonio Laguna-Camacho
PhD Student

David Booth (Prof.)
Supervisor

Email for reminder of next report

To: participant
From: researcher
Subject: Memories of eating and exercise – Report [number X]

This is a reminder to report your newly read weight this week, with the timings of recent occasions of eating and exercise as described in the other questions.

Please log into the study titled 'Experiment using memories of eating and exercise - Report [number of report]' on the RPS website, http://birmingham.sona-systems.com/

Before doing your report you should take your weight reading, preferably after getting up and before your usual meal, having relieved yourself and wearing at most light clothing with no shoes.

Many thanks for continuing to work with me on this research.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham

Email requesting change in frequency of a habit

HiFat condition: first request

To: Participant
From: Researcher
Subject: request for a change – Memories of eating and exercise

Dear Participant,

Thank you for completing the latest weekly report. This is the first request that you change how often you do one of the habits you've been recalling, while not changing other eating or exercise at the same time.

Looking at your and others' memories of eating, it seems feasible for you to have meals less often that are based on fat-rich food, e.g. cheese, sausages, streaky bacon, fried bread, lots of fatty spread or oil. As soon as you can, please start making a change to an extent that you can maintain until at least the end of Term. That should be a bit better for your health.

If you don't want to (or can't) make this change, though, please tell me and I'll let you know the next habit in the sequence assigned to you so that you can consider changing it instead.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham

HiCHO condition: first request

To: Participant
From: Researcher
Subject: request for a change – Memories of eating and exercise

Dear Participant,

Thank you for completing the latest weekly report. This is the first request that you change how often you do one of the habits you've been recalling, while not changing other eating or exercise at the same time.

Looking at your and others' memories of eating, it seems feasible for you to have meals more often that are low in fat and have very little protein, e.g., pasta topped with tomato sauce, a salad, baked potato, bread with Marmite or jam, a dish based on vegetables only, toast with marmalade only. As soon as you can, please start making a change to an extent that you can maintain until at least the end of Term. That should be a bit better for your health.

If you don't want to (or can't) make this change, though, please tell me and I'll let you know the next habit in the sequence assigned to you so that you can consider changing it instead.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham

EnBM condition: first request

To: Participant
From: Researcher
Subject: request for a change – Memories of eating and exercise

Dear Participant,

Thank you for completing the latest weekly report. This is the first request that you change how often you do one of the habits you've been recalling, while not changing other eating or exercise at the same time.

Looking at your and others' memories of eating, it seems feasible for you to have snackfoods and drinks with calories in them less often between meals, e.g., crisps, sweets, chocolate bar, cake, biscuits, apple juice, Coca cola, beer, vodka, coffee with cream and/or sugar. As soon as you can, please start making a change to an extent that you can maintain until at least the end of Term. That should be a bit better for your health.

If you don't want to (or can't) make this change, though, please tell me and I'll let you know the next habit in the sequence assigned to you so that you can consider changing it instead.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham

EnWM condition: first request

To: Participant
From: Researcher
Subject: request for a change – Memories of eating and exercise

Dear Participant,

Thank you for completing the latest weekly report. This is the first request that you change how often you do one of the habits you've been recalling, while not changing other eating or exercise at the same time.

Looking at your and others' memories of eating, it seems feasible for you to have snackfoods and drinks with calories in them less often as part of a meal or a little before the meal, e.g. crisps, sweets, chocolate bar, cake, biscuits, apple juice, Coca cola, beer, vodka, coffee with cream and/or sugar. As soon as you can, please start making a change to an extent that you can maintain until at least the end of Term. That should be a bit better for your health.

If you don't want to (or can't) make this change, though, please tell me and I'll let you know the next habit in the sequence assigned to you so that you can consider changing it instead.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham

HiFat condition: second request

To: Participant
From: Researcher
Subject: 2nd request for a change - Memories of eating and exercise

Dear Participant,

Thank you for completing the latest weekly report. This is the second request that you change how often you do one of the habits you've been recalling.

Please do not change any other eating or exercise at the same time, and also maintain the change of the first habit requested to the extent that is ok for you.
Looking at your and others' memories of eating, it seems feasible for you to have meals less often that are low in fat and have very little protein, e.g., pasta topped with tomato sauce, a salad, baked potato, bread with Marmite or jam, a dish based on vegetables only, toast with marmalade only.

As soon as you can, please start making a change to an extent that you can maintain until the last week you continue doing reports over this semester. This will help to measure across the group how the weight changes with a change in how often you do each habit.

If you don't want to (or can't) make this change, though, please tell me and I'll let you know the next habit in the sequence assigned to you so that you can consider changing it instead.

Antonio Laguna-Camacho
PhD Student, School of Psychology, University of Birmingham