



Dieting and the self-control of eating in everyday environments: An experience sampling study

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Objective. The literature on dieting has sparked several debates over how restrained eaters differ from unrestrained eaters in their self-regulation of healthy and unhealthy food desires and what distinguishes successful from unsuccessful dieters. We addressed these debates using a four-component model of self-control that was tested using ecological momentary assessment, long-term weight change, and a laboratory measure of inhibitory control.

Design. A large sample of adults varying in dietary restraint and inhibitory control (as measured by a Stroop task) were equipped with smartphones for a week. They were beeped on random occasions and provided information on their experience and control of healthy and unhealthy food desires in everyday environments.

Main outcome measures. The main outcome measures were desire strength, experienced conflict, resistance, enactment of desire, and weight change after a 4-month follow-up.

Results and conclusions. Dietary restraint was unrelated to desire frequency and strength, but associated with higher conflict experiences and motivation to use self-control with regard to food desires. Most importantly, relationships between dietary restraint and resistance, enactment of desire, and long-term weight change were moderated by inhibitory control: Compared with dieters low in response inhibition, dieters high in response inhibition were more likely to attempt to resist food desires, not consume desired food (especially unhealthy food), and objectively lost more weight over the ensuing 4 months. These results highlight the combinatory effects of aspects of the self-control process in dieters and highlight the value in linking theoretical process frameworks, experience sampling, and laboratory-based assessment in health science.

Statement of contribution

What is already known on this subject? Dieting is a multifaceted process that can be viewed from the lens of self-control. Dietary restraint measures can be used to capture dieting status, but it is relatively unclear what differentiates successful from unsuccessful dieters (e.g., differences in desire frequency, desire strength, motivation, executive functions).

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What does this study add?

- A novel four-step conceptual model of self-control is applied to eating behaviour in everyday life. This model allows a fine-grained look at the self-control process in restrained eaters (dieters) as compared to non-dieters.
- Dieters and non-dieters do not differ in desire frequency and strength (they are not simply more tempted).
- Dieters high (as compared to low) in inhibitory control are more likely to engage in self-control.
- Dieters high (as compared to low) in inhibitory control are more likely to resist unhealthy food desires.
- Dieters high (as compared to low) in inhibitory control are more likely to lose weight over a 4-month period.
- Together, the study shows clear differences among successful and unsuccessful dieters that can be linked to differences in executive functioning (inhibitory control).
- The present article is one of the first studies combining a conceptual model with smartphone experience sampling to study weight control and thus paradigmatic from a methodological perspective.

The Western 'obesogenic environment' is characterized by the abundant availability of palatable but unhealthy food (French, Story, & Jeffery, 2001; Hill & Peters, 1998; Wardle, 2007). The obesogenic environment has resulted in an increasing number of people who attempt to control their weight. A study in *Nature* reported that over 70% of US adults reported attempting to curb calories, reduce quantity of food intake, reduce fat, or raise exercise levels at least once across a 4-year period (French, Jeffery, & Murray, 1999). People who frequently or regularly try to control their weight by limiting their caloric intake are referred to as chronic dieters or restrained eaters.

Unfortunately, restrained eaters are often unsuccessful in controlling their weight (Mann *et al.*, 2007). For instance, whereas restrained eaters' eating behaviour is characterized by periods of restriction, these efforts at restraint are often undermined by lapses and periods of overeating (Gorman & Allison, 1995). Accordingly, researchers have found that people scoring high on dietary restraint often do not consume fewer calories, on average, compared to individuals with low scores on dietary restraint despite being motivated to do so (Stice, Cooper, Schoeller, Tappe, & Lowe, 2007; Stice, Fisher, & Lowe, 2004).

Many explanations have been proposed for problems regulating food intake. For instance, it could be that restrained eaters are more vulnerable to the hedonic appeal of unhealthy foods than non-dieters and therefore experience stronger desires for unhealthy foods (Lowe & Butryn, 2007; Stroebe, Papies, & Aarts, 2008). Some evidence for this notion comes from research showing that compared with unrestrained eaters, restrained eaters experience more spontaneously activated hedonic thoughts when exposed to tempting food (Papies, Stroebe, & Aarts, 2007) and appear to have problems in down-regulating hedonic affective reactions to tempting food (Hofmann, Koningsbruggen, Stroebe, Ramanathan, & Aarts, 2010).

Moreover, dieters' frequent failures might be linked to ineffective inhibitory control or executive functioning (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). According to this account, the inability to inhibit pre-potent impulses and desires is central to self-regulation failure (Allan, Johnston, & Campbell, 2010; Guerrieri, Nederkoorn, & Jansen, 2007; Hofmann, Friese, & Wiers, 2008; Nederkoorn, Van Eijs, & Jansen, 2004; Nederkoorn *et al.*, 2010). For example, recent laboratory research demonstrated

that dieters who are poor in inhibitory control consumed more chocolate during a taste test than those with strong inhibitory control (Allan *et al.*, 2010). Accordingly, improving inhibitory control through training has been shown to predict decreased sweet consumption among restrained eaters (Houben & Jansen, 2011). This research points to the idea that whereas dietary restraint measures *per se* have been found to be poor predictors of weight change (Stice *et al.*, 2004, 2007; Tiggemann, 1994), they may be better predictors *in combination* with individual differences in inhibitory control of who gains versus loses weight.

The research on why dieters often fail to adhere to their intentions thus points to several possibilities as to where self-control failures might occur during the process of managing food desires. In most studies, however, researchers have looked at food consumption or weight loss in isolation, that is, at the ultimate outcome variables of the self-control process, but not at the underlying process mechanisms that give rise to these outcomes. For instance, a number of scholars have argued that most approaches do not distinguish clearly between the strength of a given desire and the capacity to control a desire (Herman & Polivy, 2004; Hofmann, Friese, & Strack, 2009; Hofmann *et al.*, 2008; Rawn & Vohs, 2011). Moreover, studies that have investigated underlying mechanisms for overeating among dieters are generally conducted in controlled (and somewhat artificial) laboratory settings (Fedoroff, Polivy, & Herman, 1997; Herman & Mack, 1975; Hofmann & Friese, 2008; Hofmann, Rauch, & Gawronski, 2007; Papies *et al.*, 2007; Ward & Mann, 2000). While studying eating in laboratory settings has many benefits (e.g., Schachter, Goldman, & Gordon, 1968), research situated in people's natural eating environments is a neglected approach that may help to cross-validate findings obtained in more controlled settings as well as offer its own unique insights (Tomiyama, Mann, & Comer, 2009).

A four-component framework of the self-control of eating behaviour

Here, we apply a general theoretical framework for the study of desire and self-control in everyday life that was recently proposed (Hofmann, Baumeister, Förster, & Vohs, 2012) to the case of dieting. We suggest four components that, considered jointly, allow for a fine-grained analysis of where in the self-control process dieters fail or succeed: Desire strength, conflict, resistance (i.e., use of self-control), and the enactment of behaviour. The first component, *desire*, deals with the strength of the urges that a person experiences. In this study, we tested the hypotheses that restrained eaters experience more frequent food desires and/or suffer from stronger desires and thus are in a disadvantageous position 'from the start' as compared to unrestrained eaters.

The second component, *conflict*, reflects the degree to which people perceive that a desire stands in opposition with their long-term goals, thereby turning the desire into a *temptation* (Hofmann, Baumeister, *et al.*, 2012). The identification of a conflict between what one desires to do and what one should be doing is an important trigger for self-control efforts (Carver & Scheier, 1981; Hofmann, Baumeister, *et al.*, 2012; Myrseth & Fishbach, 2009). Yet despite knowing that conflicts are important instigators of self-control processes, little research has been devoted to measuring the degree to which dieters versus non-dieters feel conflicted about their food desires.

The third component, *resistance*, describes the degree to which a person attempts to override the desire for food through self-control. The degree to which dieters attempt to resist a given food desire should be strongly related to the degree to which they feel

conflicted about that desire. However, distinguishing between conflict and resistance is important, because dieters may not always decide to resist a given food craving when experiencing conflict. For instance, some dieters may believe that their chances of being able to resist successfully are so low that they do not even attempt to do so.

The fourth component, *enactment*, reflects the behavioural outcome of the motivational processes from desire to possible conflict to possible resistance. In the case of a non-conflicting desire, enactment of the desire would in most cases be the natural endpoint of that process. In the case of an active resistance attempt, however, enactment signifies *self-control failure* because the person behaved in a way that was contrary to his or her intentions (Hofmann, Baumeister, et al., 2012; Stroud & Tappolet, 2003).

Research objective and hypotheses

The purpose of this work was to gain a fine-grained understanding of how and why chronic dieters (restrained eaters) differ in their self-regulation of everyday food intake from non-dieters (unrestrained eaters) using smartphone experience sampling technology. To do so, we decomposed the self-control process into the four conceptual components just described (desire, conflict, resistance, enactment). In addition, we collected follow-up data on self-reported weight change over 4 months as a long-term behavioural outcome. We expected dieters to experience more frequent and stronger food desires than others on average, in accordance with hedonic theories of overeating. We also assumed that dieters would feel more conflicted about their food desires given the structural conflicts between many food desires and dieting goals. Consequently, we expected chronic dieters to use self-control more often than non-dieters. However, based on the above findings on the difficulties of dieting, we expected that dieters would do little better on average than non-dieters with regard to their enactment of food desires (Stice et al., 2004, 2007), especially on self-control occasions. These difficulties were expected to result in a non-significant overall relationship between dietary restraint and weight loss, as other work has found (Mann et al., 2007; Tiggemann, 1994).

Because it is plausible that healthy and unhealthy foods take on different meanings for chronic dieters as opposed to non-dieters, we also distinguished between healthy and unhealthy foods in conducting these analyses. From a nutritional perspective, both healthy and unhealthy foods can lead to weight gain if consumed in abundance. Yet, chronic dieters may not perceive food intake in this way. A recent study has suggested that people – especially those high in dietary restraint – can harbour erroneous beliefs about the relationship between a meal's healthiness and its (limited or null) effects on weight gain (Chernev, 2011). This research showed that weight-conscious individuals often behave as though eating healthy foods in addition to unhealthy ones will actually decrease (not increase) a meal's calorie count. Thus, chronic dieters may feel reduced levels of conflict towards healthy foods as compared to unhealthy foods that may result in lower rates of resisting these foods.

To get at a better understanding of self-control failures in dieting, we also investigated the role of *inhibitory control* (Hofmann et al., 2008; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Because the capacity to inhibit pre-potent impulses has been implied as a major determinant of effective self-regulation, we expected inhibitory control to help distinguish between successful and unsuccessful dieters. Specifically, we hypothesized that dieters low in inhibitory control should show more self-control failures and less weight loss over time than dieters high in inhibitory control. Because inhibitory control may also affect the motivation to resist

problematic food desires or even further 'upstream' components such as desire strength and conflict, we explored its possible moderator role with regard to these components from our conceptual framework as well.

The present method, experience sampling, allows researchers to learn what people are thinking, feeling, and doing at specific moments in their lives (e.g., Csikszentmihalyi & Larsen, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2006). Some previous research has adopted this method to study specific eating disorders such as bulimia (Johnson & Larson, 1982; Steiger, Lehoux, & Gauvin, 1999; Vansteelandt *et al.*, 2004), eating behaviour among adolescents (Richards, Casper, & Larson, 1990; Swarr & Richards, 1996), and situational triggers of overeating such as emotional states and stress (Kubiak, Vogeles, Siering, Schiel, & Weber, 2008; Macht & Simons, 2000; Tomiyama *et al.*, 2009). To the best of our knowledge, however, no prior research has combined this method to cover the whole self-control process from desire to behaviour enactment and long-term weight change in order to understand how restrained and unrestrained eaters self-regulate their everyday eating behaviour.

Method

Overview

We analysed food data from the recent Everyday Temptation Study (Hofmann, Baumeister, *et al.*, 2012), which is a large experience sampling database on more than 7,000 desires from 15 different domains. The by far most often mentioned type of desire (28.1%) was food related with the 2,203 food desires forming the database for the present set of analyses. The experience sampling phase of the project was complemented by a laboratory assessment of dietary restraint and inhibitory control and by a follow-up assessment of self-reported weight change 4 months after the experience sampling was finished.

Participants

The initial sample included 208 participants (66% women) from the city of Würzburg, Germany, and its surroundings. Participants were aged 18–55 ($M = 25.24$, $SD = 6.32$), and 73% were university students. The student part of the sample was heterogeneous, involving 49 different fields of study. The remaining 27% of participants were either full- or part-time employed (13.9%), currently doing an apprenticeship (3.4%), high-school students (1.9%), unemployed (1.4%), retirees (1%), or other (5.3%). Experience sampling data from three participants were lost due to technical problems. One participant did not report any food desires. Hence, the final sample consisted of 204 participants. BMI of participants averaged 22.83 ($SD = 3.19$) and ranged from 16.02 to 35.57.

Experience sampling procedure

During an orientation meeting, participants were provided with Blackberry smartphones that were disabled for placing or receiving calls. They were informed about the general purpose of the study, received both oral and written instructions, and provided informed consent. Participants carried the smartphones wherever they went for a duration of 1 week. A Java ME programmed smartphone application controlled the signalling schedule, questionnaire presentation, and data saving on the device. On each experience sampling day, seven signals were distributed throughout a time-window of 14 hr

(participants could customize the starting time for each day to either 8, 9, or 10 am). Within each 2-hr block of this time-window, one signal was randomly chosen so as to spread out signals equally throughout the day. If the smartphone was turned off at the time of the signal, the program rescheduled the signal at a later point in the present or next time block; however, if the smartphone was off until the next time block ended, the response was recorded as missing.

Experience sampling protocol

At the onset of each signal, participants first indicated whether they were currently experiencing a desire or had been experiencing a desire within the last 30 min. If they indicated no desire, the assessment period was over. If they indicated a desire, they next indicated the content of the desire. Participants were provided with a list of 15 domains (food, non-alcoholic drinks, alcohol, coffee, tobacco, other substances, sex, media, spending, work, social, leisure, sleep, hygiene-related, other). These were further branched into a total of 79 subdomains, drawn from the self-regulation literature and based on pre-testing. For the category of food desires, the subdomains were as follows: 'primarily healthy dish', 'primarily hearty dish', 'fast food main dish', 'sweet main dish', 'healthy snack', 'fast food as snack', 'sweet snack (chocolate, ice cream, etc.)', and 'nibbles (chips, etc.)'. Under the response option 'other', participants could also provide a self-generated response using the keyboard on the smartphone.

Next participants indicated the peak strength of the desire on a scale from 0 (*no desire at all*) to 7 (*irresistible*) and whether they had attempted to resist the desire (*yes vs. no*). They then indicated (*yes vs. no*) whether they had enacted the behaviour suggested by the desire (even to some extent, e.g., eating some of a chocolate bar without eating the entire bar would count as enactment). Finally, participants rated the degree to which the given desire conflicted with one or more personal goal(s) on a scale from 0 (*no conflict at all*) to 4 (*very high conflict*). On a random subset of occasions (60%), participants also indicated their location, level of stress, arousal, and to what degree they were currently under the influence of alcohol. As these variables had many missing occasions and are not in the focus of the present investigation, we will not discuss them further.

Two to 4 days after the experience sampling phase, participants completed a variety of measures including demographic indicators (e.g., sex, age, occupation, weight), a measure of dietary restraint, and an experimental assessment of inhibitory control (described below). They were then debriefed and paid for their participation. Participants were reimbursed with a base compensation of €20 (approximately \$28) and received additional incentives (movie passes, music player raffle tickets) if they completed more than 80% of signals. Participants completed 92.2% of signals on average.

Dietary restraint scale

Dietary restraint was assessed with the Concern for Dieting subscale of the Revised Restraint Scale (Herman & Polivy, 1980). The mean score across the six items with a response scale from 1 to 4 was 2.03 ($SD = .56$; $\alpha = .75$). Following Stein (1988) who argued against arbitrary cut-offs and unnecessary loss of information due to dichotomization, dietary restraint was treated as a continuous variable (see also Papies, Stroebe, & Aarts, 2009; Tomarken & Kirschenbaum, 1984). For the sake of succinctness, we will refer to people above average (+1 SD) on the scale as 'dieters' or 'restrained eaters' and to people below average (-1 SD) on the scale as 'non-dieters' or 'unrestrained eaters'.

Measure of inhibitory control

Inhibitory control was assessed with the Stroop (1935) task, a task commonly classified as a measure of pre-potent response inhibition (Friedman & Miyake, 2004; Miyake *et al.*, 2000). Participants responded to the colour of a word presented on a white background as quickly as possible using four response keys (red, green, blue, and black). The test block consisted of 84 trials, including 28 congruent trials, 28 incongruent trials, and 28 non-word filler trials (simple rectangles that varied in colour), drawn in random order. During congruent trials, the meaning of the words and the colour in which they were presented were compatible (e.g., 'red' presented in red ink). During the incongruent trials, the meaning of the words was incompatible with the colour in which they were presented (e.g., 'red' in green ink), and hence, the pre-potent response to react in accordance with the word meaning has to be inhibited. To compute a measure of Stroop interference, we subtracted the mean log-transformed response latencies for congruent trials from the mean log-transformed response latencies on incongruent trials for each participant (non-word trials were not included). The average Stroop effect was significant, $M_{\log} = .19$ (untransformed $M = 189.86$ ms), $SD = .12$, $t(203) = 22.91$, $p < .001$, indicating the expected interference on incongruent trials. We then reversed this difference score such that higher scores indicate better inhibition (i.e., smaller Stroop effect).

Weight change over 4 months

Self-reported weight in kilogram was assessed at the end of the experience sampling phase and again through an online survey distributed 4 months later. Response rate to the follow-up survey was satisfactory (78%; $N = 160$). The difference in weight from the testing phase to the follow-up served as our measure of medium-term weight change, with positive scores representing weight gain and negative scores representing weight loss. The mean self-reported weight difference was $M = 0.46$ kg ($SD = 2.80$), which differed from zero, $t(159) = 2.06$, $p = .041$, indicating that the average participant gained some weight over time.

Coding of healthy and unhealthy food desires

Participant experience sampling responses in the subdomain category 'other' ($n = 100$) were screened by two independent raters. The majority of these responses ($n = 63$) could be reassigned to the remaining subdomains, leaving 37 responses in the category 'other', which were excluded from further analyses (inter-rater agreement $\kappa = .95$). We categorized participants' remaining desire responses to food ($N = 2,166$) into healthy and unhealthy food desires based on the answers on the subdomain level. Desires for 'primarily healthy dish' and 'healthy snack' were assigned to the healthy food craving category, and desires for 'primarily hearty dish', 'fast food main dish', 'sweet main dish', 'fast food as snack', 'sweet snack (chocolate, ice cream, etc.)', and 'nibbles (chips, etc.)' were assigned to the unhealthy food craving category.

Experience sampling data aggregation

To address whether participants high in dietary may be more pre-occupied with food, we calculated, for each participant, the relative percentage of healthy ($M = 11\%$, $SD = .09$) and unhealthy food desires ($M = 18\%$, $SD = .11$) with regard to the overall number of desires mentioned during the experience sampling period. All remaining measures were

computed from the subset of food-related desires in the database. Specifically, we computed, for each participant, the following measures both across all food desires (overall score) and separately for healthy and unhealthy food desires: (1) average desire strength, (2) average rating of conflict, (3) average probability that the participant attempted to resist the food desire, (4) average probability that the participant enacted a food desire (implying consumption of the food), and (5) average probability that the participant enacted a food desire that he or she had attempted to resist (self-control failure rate).

Results

What kind of food desires do people have?

We categorized the types of food desires that people reported having into healthy versus unhealthy (see Method section). Participants indicated a total of 836 desires for healthy food and 1,330 desires for unhealthy food, thereby reporting on average almost 60% more desires for unhealthy foods than healthy foods.

Is dietary restraint associated with the frequency of food desires?

We first assessed whether dietary restraint was related to the frequency of food desires. It was not. Dietary restraint was uncorrelated with both the absolute reported frequencies of desires for food overall, $r = -.01$, $p = .84$, for healthy food, $r = .05$, $p = .51$, or for unhealthy food, $r = -.05$, $p = .47$, as well as with percentage scores that reflected the percentage of food desires among the overall number of desires reported ($r_{\text{overall}} = .02$, $p = .31$; $r_{\text{healthy}} = .07$, $p = .31$; unhealthy food, $r_{\text{unhealthy}} = -.01$, $p = .93$). Hence, chronic dieters experienced food desires just as often as non-dieters.

How does dietary restraint affect desire strength, conflict, resistance, behaviour enactment, and weight change?

Descriptive statistics for all main measures are provided in Table 1. We ran simple regression analyses to test how dietary restraint relates to the four components of our framework (desire strength, conflict, likelihood of resistance, likelihood to enact) as well as on self-reported weight change. For each dependent variable, we performed three

Table 1. Descriptive statistics for all measures

Variable	<i>M</i>	<i>SD</i>	Minimum	Maximum
Desire strength	4.03	.87	1	7
Conflict	0.86	.79	0	4
Resistance	0.42	.25	0	1
Enactment	0.48	.23	0	1
Self-control failure rate	0.25	.31	0	1
Self-reported weight change	0.46	2.80	-14	10
Dietary restraint	2.03	.55	0	3.83
Stroop interference (log-transformed)	0.19	.12	-0.13	0.56

Note. $N = 204$ for all variables except for self-reported weight change ($N = 160$).

regression analyses: one overall model and two ancillary analyses that used healthy and unhealthy food desires as dependent variables separately. We estimated predicted values based on regression equations for people 1 *SD* above and below the dietary restraint score mean (Table 2). Controlling for gender in additional supplementary analyses did not affect any of the statistical conclusions drawn.

Strength of food desires was not reliably related to dietary restraint scores in any of the three analyses, indicating that dieters did not experience stronger food desires than non-dieters. (An analysis showed that this null finding was unqualified by whether the desire was enacted.) Regarding feelings of conflict, dietary restraint was positively related to conflict for the overall analysis, such that people high (+1 *SD*) in dietary restraint experienced higher levels of conflict than those low (−1 *SD*) in dietary restraint. This effect was driven entirely by the association between dietary restraint and conflict towards unhealthy food.

Moreover, people high in dietary restraint reported using self-control more often (48%) than those low in restraint (35%) to resist their desires for food. This effect was most pronounced for unhealthy foods but the pattern remained for healthy foods as well. Self-control failure rates (enactment given resistance) also differed (marginally) as a function of dietary restraint, such that people high in dietary restraint had a higher self-control failure rate overall and in particular with regard to unhealthy foods (Table 2). Finally, in line with the notion that dietary restraint does not discriminate between successful and unsuccessful dieters, dietary restraint scores did not predict self-reported weight change over time, $\beta = -.07, p = .405$.

The moderating role of inhibitory control

To investigate whether the relation between dietary restraint and the four components of everyday self-regulation hinges on people’s inhibitory control capacity, we conducted separate moderated regression analyses for each of these dependent variables. For each analysis, we entered dietary restraint and inhibitory control as mean-centred predictor variables and the product from these mean-centred predictors to estimate the interaction

Table 2. Desire strength, conflict, resistance, and enactment as a function of dietary restraint

	Desire strength	<i>p</i>	Conflict	<i>p</i>	Resistance	<i>p</i>	Enactment	<i>p</i>	Self-control failure rate	<i>p</i>
Foods overall										
DR β coefficient	−0.09	.191	0.40	<.001	.27	<.001	.07	.343	.13	.075
Low (−1 <i>SD</i>) DR	4.11		0.55		.35		.46		.21	
High (+1 <i>SD</i>) DR	3.95		1.17		.48		.50		.29	
Healthy foods										
DR β coefficient	−0.03	.720	0.06	.426	.15	.047	.01	.881	.10	.262
Low (−1 <i>SD</i>) DR	4.03		0.54		.31		.50		.16	
High (+1 <i>SD</i>) DR	3.97		0.63		.41		.51		.23	
Unhealthy foods										
DR β coefficient	−0.09	.225	0.43	<.001	.27	<.001	.04	.272	.13	.090
Low (−1 <i>SD</i>) DR	4.16		0.59		.36		.46		.23	
High (+1 <i>SD</i>) DR	3.98		1.40		.51		.51		.32	

Note. DR, dietary restraint (treated as continuous variable).

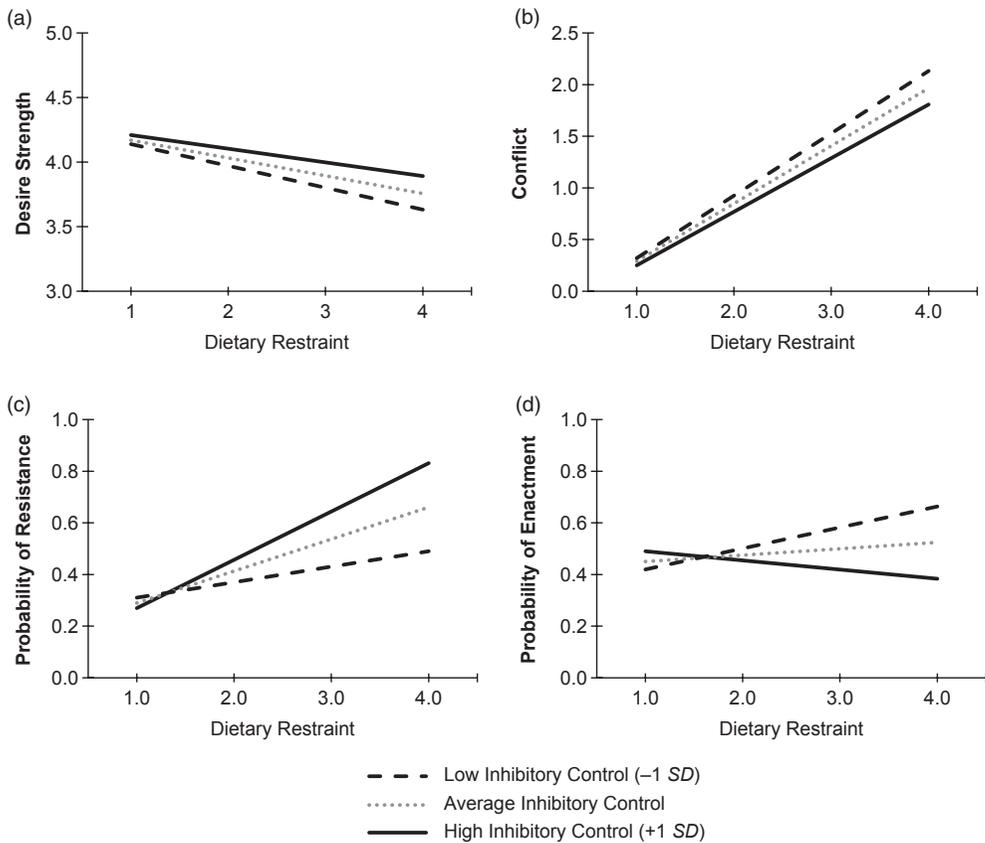


Figure 1. Effects of dietary restraint and inhibitory control on the first four components of the conceptual framework, desire strength (a), conflict (b), resistance (c), and behaviour enactment (d).

term (Aiken & West, 1991) using the macro by Hofmann (2010). The predicted simple slopes for those high (+1 *SD*), average (sample mean), and low (-1 *SD*) on inhibitory control are displayed in Figure 1 (a-d) across the range of the dietary restraint scale. A preliminary correlational analysis showed that the two predictors, dietary restraint and inhibitory control, were fully independent from each other, $r = .04$, $p = .610$.

Did inhibitory control ability change the experience of desire strength or conflict for people who vary in dietary restraint tendencies? No. Inhibitory control scores did not moderate the (non-significant) relationship between dietary restraint and desire strength, $\beta = -.02$, $p = .776$, nor the positive relationship between dietary restraint and conflict, $\beta = .03$, $p = .654$ (Figure 1a,b). However, whether restrained eaters were high rather than low in inhibitory control had a significant impact on the likelihood of resisting food desires, $\beta = -.15$, $p = .034$ (see Figure 1c). Simple slope tests revealed that the regression slope of dietary restraint on resistance was significantly positive for those high (+1 *SD*) in inhibitory control, $\beta = .42$, $p < .001$, but it was not different from zero for those low in inhibitory control, $\beta = .13$, $p = .154$. A second simple slope test (conducted at 1 *SD* above the dietary restraint mean) indicated that those high in inhibitory control attempted to resist food desires more often than those low in inhibitory control, $\beta = .32$, $p = .004$ (the difference was not significant at 1 *SD* below the mean, $\beta = .03$, $p = .749$).

Ancillary analyses revealed that the interaction was driven by attempts to resist healthy food, $\beta = -.12, p = .093$, rather than unhealthy food, $\beta = -.08, p = .251$.

Inhibitory control also moderated the relationship between dietary restraint and the overall likelihood with which food desires were enacted (irrespective of resistance), $\beta = .14, p = .05$: Restrained eaters low in inhibitory control were considerably more likely to enact food desires than those high in inhibitory control (see Figure 1d), as confirmed by a simple slope test, $\beta = .24, p = .035$ (the simple slope for those below average in dietary restraint was not significant, $\beta = -.04, p = .650$). Ancillary analyses confirmed that the interaction effect was driven by unhealthy foods, $\beta = .21, p = .004$, rather than healthy foods, $\beta = -.04, p = .589$.

To test whether this moderator effect was primarily due to instances in which dieters attempted to resist their urges, we conducted a similar analysis as the above using self-control failure (i.e., probability of enactment given resistance) as dependent outcome. This analysis revealed a moderator effect with regard to the self-control of unhealthy foods, $\beta = .17, p = .030$, but not with regard to healthy foods, $\beta = .001, p = .986$ (overall analysis, $\beta = .08, p = .294$). Simple slope tests showed that dietary restraint was a reliable predictor among individuals low, $\beta = .29, p = .007$, but not high in inhibitory control, $\beta = -.05, p = .662$ (Figure 2). Simple slope tests also confirmed that restrained eaters high in inhibitory control were far less likely than those with low inhibitory capacity to enact the desire for unhealthy foods that they had attempted to resist, as confirmed by a simple slope test, $\beta = -.31, p = .014$ (the simple slope at -1 SD of dietary restraint was not significant, $\beta = .03, p = .754$). Furthermore, confirming that individual differences in inhibitory control are particularly germane to the use of self-control (a specificity effect), inhibitory control scores did not moderate enactment rates on occasions on which people did not indicate resistance, all three interaction p s $> .389$.

Finally, we investigated whether inhibitory control scores predicted self-reported weight change. As expected, a negative interaction effect emerged, $\beta = -.17, p = .040$ (Figure 3). Simple slope tests showed that dietary restraint was a reliable predictor of weight loss only among those high in inhibitory control, $\beta = -.25, p = .034$, but not among those low in inhibitory control, $\beta = .08, p = .455$ (Figure 3). People high (+1 SD) in dietary restraint lost considerably more weight on average over the 4-month

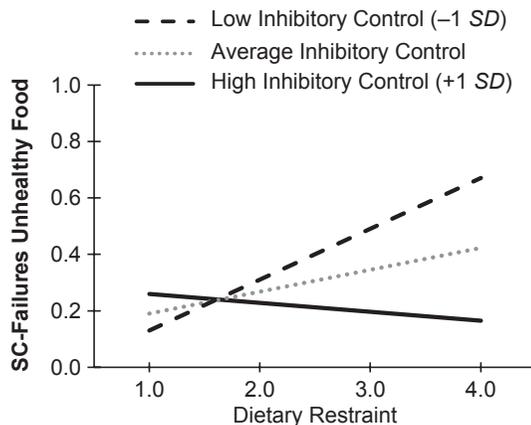


Figure 2. Moderator effect of inhibitory control on the relationship between dietary restraint and the percentage of self-control failures with regard to unhealthy food desires.

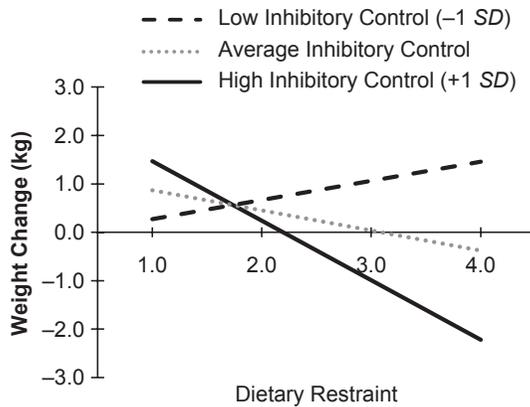


Figure 3. Moderator effect of inhibitory control on the relationship between dietary restraint and weight change over a 4-month period after the experience sampling phase.

interval if they were high ($M = -0.57$ kg at $+1$ SD) rather than low ($M = 0.92$ kg $+1$ SD) in inhibitory control, as confirmed by a simple slope test, $\beta = -.27$, $p = .038$ (the simple slope for those below average in dietary restraint was not significant, $\beta = .07$, $p = .508$).

Discussion

The present research investigated the connection between chronic dieting (dietary restraint) and the self-regulation of food desires in everyday environments. To this end, we combined a novel conceptual framework for the analysis of self-regulation processes (distinguishing desire, conflict, resistance, and enactment) with smartphone experience sampling technology as well as a laboratory assessment of inhibitory control. We found both a number of expected results regarding the everyday manifestation of dieting and a number of surprising results that have the potential to change views on the way people experience and control their food desires in their natural environments.

First, descriptively, we found that the majority of food desires were for unhealthy as compared to healthy foods. This finding suggests two interpretations. One, that unhealthy foods are tastier and therefore more alluring than healthy foods. Given the food industry's success at creating foods that hit on the evolutionary triggers of fat, salt, and sweetness (Moss, 2013), this might well be the case. Another possibility is that people crave unhealthy foods because they are off-limits. This notion has been born out in reactance research (Brehm, 1972) and in more recent work on how denial of a good leads to heightened wanting (but less liking; Litt, Khan, & Shiv, 2010). Thus, this finding might be overdetermined and because so significant that it is robust.

Second, we found a number of non-significant effects that are notable. In comparison with people lower in dietary restraint, restrained eaters did not differ in the frequency with which they experienced food desires nor in how strong their desire for food felt. These results suggest that wanting to control one's eating does not elevate the number of times nor the intensity with which one experiences the desire for food.

Third, attesting to the validity of the experience sampling method, we found significant differences between restrained and unrestrained eaters that comport with prior research. Restrained eaters reported feeling more conflicted about their food

desires, especially with regard to unhealthy food and a greater use of self-control to resist both healthy and unhealthy food desires. As for whether they were more or less successful than the unrestrained eaters at resisting the urge to give into a food desire, practice does not help in this domain as restrained eaters, on average, showed a trend for more self-control failure with regard to unhealthy foods.

Last, and most notably, our findings point to the importance of behavioural inhibition as a key variable that distinguishes successful from unsuccessful dieters. Specifically, dieters who possessed high rather than low inhibitory control abilities as measured with a Stroop task were (1) more likely to *attempt* to resist food desires and (2) when they did so, more successful at inhibiting those (unwanted) desires. A 4-month follow-up measurement demonstrated tangible outcomes associated with inhibitory control skills in finding that only dieters high in inhibitory control reported weight loss over 4 months.

Perhaps surprisingly, the effect of individual differences in inhibitory control with regard to the resistance component was strongest for healthy foods. This finding might suggest that dieters low in response inhibition may not recruit enough motivation to resist healthy food desires – those food desires identified in recent research as being particularly prone to biases in motivated reasoning (Chernev, 2011).

Despite higher average attempts to resist food desires, restrained eaters did not act on their desires regarding food any more than did unrestrained eaters, consistent with previous findings (Stice *et al.*, 2004, 2007). Once more, this pattern was strongly qualified, however, by individual differences in inhibitory control: Dieters low in inhibitory control had the worst self-control failure rates (i.e., they indulged a food desire even though they tried not to), especially when they were confronted with unhealthy food desires.

Limitations and future directions

We found that dieters with high inhibitory control did not differ in their average desire strength from those identified as less successful. This pattern suggests that chronically stronger food desires may not be the primary reason why restrained eaters often fail to restrict their food intake as planned. However, this finding may be a function of the specific restraint scale used, so replication involving alternative measures is warranted (Laessle, Tuschl, Kotthaus, & Pirke, 1989). Moreover, it is possible that the processes by which hedonic reward value translates into eating behaviour may not always be mediated by conscious subjective experience (Winkielman, Berridge, & Wilbarger, 2005) and hence may not have been fully captured by our self-report measures in this study. Future field research in this direction should therefore attempt to include indirect indicators (i.e., implicit, physiological) of desire as well.

We noted that restrained eaters who had low inhibitory control were less motivated to resist healthy foods in particular. It could be that dieters low in inhibitory control may allocate their limited inhibitory capacity towards attempting to resist unhealthy food desires while keeping their defences down with regard to healthy foods. The fact that they failed to lose weight may be partially due to the fact that the latter food group nonetheless contains unaccounted for calories. Future research on this fascinating notion would be welcome.

Given that only dieters with strong inhibitory control reported weight loss, it seems that one cannot predict whether a dieter is likely to be successful at achieving weight loss unless one also knows how well the person can inhibit pre-potent impulses. This finding

complements recent research on the role of inhibition in buffering the effects of implicit snack food preferences on long-term weight gain (Nederkoorn *et al.*, 2010). Bringing these two lines of work together, we would expect future research to find a two-way interaction among dietary restraint, inhibitory control, and implicit food preferences such that the role of inhibitory control may become most decisive in determining dietary success when individuals are both high in their commitment to a dieting goal and frequently tempted by strong (automatic) hedonic responses towards unhealthy foods.

Conclusion

To understand the complex process of dieting, it is not only important to probe how dieters react to tempting food cues in controlled laboratory settings but also to gather fine-grained information about how dieters and non-dieters experience and regulate food desires in their everyday environments. Implementing a four-component model of self-control, we found that chronic dieters do not report to experience more frequent or more intense food desires on average than non-dieters, feel much more conflicted about their food desires, resist their food desires more often than non-dieters, and show a trend for more self-control failures with regard to unhealthy foods. Most important, whether dieters were successful at resisting problematic desires and whether they actually lost weight over time depended strongly on their inhibitory control capacity, in line with recent insights into the intricate connection between executive functions and self-regulation (Hofmann, Schmeichel, & Baddeley, 2012). Taken together, the current study demonstrates that the psychology's understanding of eating behaviour may be advanced through the integration of conceptual theoretical frameworks and ecologically valid assessment tools that go beyond one-time assessments of attitudes, intentions, or behaviour in the field. As new smartphone technology evolves, allowing health scientists to follow participants deeper and deeper into the 'trenches' of their everyday regulatory struggles and successes (Berkman, Falk, & Lieberman, 2011; Miller, 2012), the field of health psychology may arrive at a more complete picture of why it is so hard for some people to stay on top of their health goals and to devise more customized interventions to change that state of affairs.

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