Behaviour Research and Therapy 49 (2011) 771–780

Contents lists available at SciVerse ScienceDirect

Behaviour Research and Therapy

journal homepage: www.elsevier.com/locate/brat

Using stop signals to inhibit chronic dieters' responses toward palatable foods☆

Harm Veling*, Henk Aarts, Esther K. Papies

Department of Psychology, Utrecht University, PO Box 80140, 3508 TC Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 15 October 2010
Received in revised form
15 August 2011
Accepted 24 August 2011

Keywords:
Dieting
Impulse
Inhibition
Food
Self-control

ABSTRACT

Palatable foods in the environment can unintentionally trigger reactions to obtain them, which may interfere with dieting attempts. We tested a strategy to facilitate dieting behavior that makes use of behavioral stop signals that should instantly inhibit chronic dieters' responses toward palatable foods. Participants performed a go/no-go task in which go cues and no-go cues (i.e., the behavioral stop signals) were presented with pictures of palatable foods and control objects. In Study 1, we tested the immediate behavioral effect of presenting stop signals near palatable foods in a reaction time paradigm. In Study 2 we assessed consumption of palatable food that had either consistently been associated with no-go cues, or not. Results show that no-go cues instantly inhibited responses toward palatable foods especially among chronic dieters. Moreover, across a one day period chronic dieters consumed less of a food that had consistently been associated with no-go cues. Stop signals thus appear a promising tool for chronic dieters to control behavior to palatable foods, and we discuss the merits and potential applications of this tool for facilitating dieting behavior.

In daily life, people are regularly exposed to palatable high-caloric foods that are inexpensive and easily available. Consensus is growing that such an environment renders it very hard to regulate consumption of these foods, even when people are dieting and motivated to restrain themselves (e.g., Hill & Peters, 1998; Stroebe, 2008; Wilson, 2010). Indeed, dieting attempts in food rich environments are generally not related to long-term reductions in body weight (Elfhag & Rössner, 2005; Jeffery et al., 2000; Mann et al., 2007). Nonetheless, people may pursue repeated dieting attempts, which may eventually turn them into chronic dieters (or restrained eaters; Herman & Polivy, 1980). However, despite their continuous motivation to restrict their eating (Chernyak & Lowe, 2010; Gorman & Allison, 1995), chronic dieters have been shown to eat just as much, or even more, than nondieters (or unrestrained eaters) when exposed to palatable foods (e.g., Fedoroff, Polivy, & Herman, 1997; Jansen & van den Hout, 1991; Papies & Hamstra, 2010; Stice, Fisher, & Lowe, 2004; Stirling & Yeomans, 2004), and have even been found to gain more weight than nondieters in the long run (e.g., Klesges, Isbell, & Klesges, 1992; Stice, Cameron, Killen, Hayward, & Taylor, 1999; Stice, Presnell, Shaw, & Rohde, 2005).

Why is it so difficult for chronic dieters to restrict their food intake in food rich environments? Contemporary approaches to self-control suggest that part of the answer may be found in the fact that that perception of palatable high-caloric foods can trigger psychological processes that facilitate behavior toward these foods despite intentions to act otherwise (Hofmann, Friese, & Wiers, 2008; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). This perspective suggests that knowledge on how to modify these psychological processes may be helpful for developing new interventions to control behavior toward palatable food more effectively (e.g., Hofmann et al., 2008). The present work was conducted to provide new insight into this topic by examining whether stop signals can be effective in controlling chronic dieters' unintentional motor impulses toward palatable foods.

Several models of self-control indicate that one important proximal determinant of behavior toward tempting palatable foods is the unintentional elicitation of motor impulses toward these foods when they are encountered (e.g., Hofmann et al., 2008; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). The palatable aspect of foods may be conceived of as a reward signal that the food is worth obtaining (e.g., Custers & Aarts, 2010), and hence immediately, and unintentionally (i.e., upon mere perception of the food), prepares action to obtain the food. Consistent with these models, research has shown that mere perception of appetitive stimuli, such as palatable foods, is sufficient to prepare motor action toward these stimuli (e.g., Krieglmeyer, Deutsch, De Houwer, & De Raedt, 2010; Seibt, Häfner, & Deutsch, 2007; Veenstra & de Jong, 2010;

☆ The work in this paper was financially supported by NWO VICI grant 453-06-002 and ZonMw grant 11510001.
* Corresponding author. Fax: +31 30 253 4718.
E-mail address: h.veling@uu.nl (H. Veling).

0005-7967/$ – see front matter
doi:10.1016/j.brat.2011.08.005

Veling & Aarts, in press-b). This immediate action preparation is likely to facilitate behavior toward these foods especially in demanding everyday situations where conscious or intentional processes are taxed by factors such as alcohol consumption, cognitive load, or time pressure (Baumeister & Heatherton, 1996; Hofmann & Friese, 2008; Strack & Deutsch, 2004). Indeed, research has demonstrated that the ability to inhibit prepared responses is crucial for the successful regulation of one's body weight, and that many individuals motivated to control their weight often fail at this impulse inhibition (e.g., Jansen et al., 2009; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010; Nederkoorn, Jansen, Mulkens, & Jansen, 2007).

An important contributor to the difficulty of chronic dieters in acting in line with their dieting goal may thus be the fact that palatable foods unintentionally elicit strong impulses to act on these foods. A number of research findings are consistent with this notion. First and very relevant to the present discussion, perception of foods has been shown to evoke stronger action tendencies to approach these foods in chronic dieters compared to nondieters (Veenstra & de Jong, 2010). Furthermore, research has shown that palatable food cues elicit hedonic, pleasure-oriented, thoughts more strongly in chronic dieters than in nondieters (Papies, Stroebe, & Aarts, 2007, 2008), and that palatable food cues elicit increased salivation responses in chronic dieters, but not in nondieters (Brunstrom, Yates, & Witcomb, 2004; Klajner, Herman, Polivy, & Chhabra, 1981). Moreover, exposure to palatable foods increases self-reported food cravings in chronic dieters (Harvey, Kemps, & Tiggemann, 2005). These cravings may result in overeating (e.g., Collins, 1978; Fedoroff, Polivy, & Herman, 2003; Jansen et al., 2009; Jansen & van den Hout, 1991), even when participants are explicitly asked not to eat any of the food (Stirling & Yeomans, 2004). Importantly, this consumption of palatable foods appears to be triggered by unintentional impulses to act on the food, as research has further shown that chronic dieters reduce their palatable food consumption once they are explicitly reminded about their dieting goal (Anschutz, Van Strien, & Engels, 2008; Papies & Hamstra, 2010; Ward & Mann, 2000).

The research discussed above suggests that chronic dieters' difficulty to control their palatable food consumption may be facilitated by unintentional impulses toward palatable foods. Considering that palatable foods are abundant in the environment (Hill & Peters, 1998; Stroebe, 2008; Wilson, 2010), an intervention that directly modifies impulses toward palatable foods may thus provide a promising route to improve self-control among chronic dieters in daily life (e.g., Hofmann et al., 2008; Veling & Aarts, in press-a).

A recent line of research suggests that one way to accomplish this goal is by presenting behavioral stop signals near palatable foods (Houben, 2011; Houben & Jansen, 2011; Veling & Aarts, 2009, in press-b; Veling, Holland, & van Knippenberg, 2008). A stop signal is a cue or sign in the environment that causes people to inhibit their behavior by suppressing any elicited motor impulses. Previous research has shown that presentation of a stop signal shortly after action preparation causes motor inhibition, which can be conceived of as a global brake on the action system (e.g., Coxon, Stinear, & Byblow, 2009; for an overview see Stinear, Coxon, & Byblow, 2009). As a result of this global braking mechanism, behavior is temporarily put on hold, and restarting of subsequent behavior is slowed down (Veling & Aarts, in press-b). In other words, presenting a stop signal shortly after action preparation inhibits the motor system and restrains all subsequent action. Moreover, strength of this motor inhibition has been shown to be a function of the strength of the initially prepared impulse (Nakata et al., 2006). Thus, stop signals have been shown to be an effective tool to disrupt and inhibit motor impulses, and stop signals are more effective as impulses are elicited stronger.

The research described above suggests that stop signals are a means that can be used to inhibit unintentional impulses toward palatable foods, and hence modify a proximal determinant of behavior toward palatable foods. Importantly, chronic dieters should benefit most of the use of stop signals as a modifier of impulses evoked by palatable foods, as stop signals produce stronger inhibition as impulses are evoked stronger, and palatable foods have been shown to trigger strong appetitive impulses especially among chronic dieters. Based on this reasoning, two studies were conducted that examined whether stop signals are indeed effective in modifying chronic dieters' responses toward palatable foods. We examined the immediate behavioral consequences of presenting stop signals near palatable foods in a reaction time paradigm, and tested the potential of stop signals to affect a clinically relevant measure of behavior (i.e., food consumption in an everyday life context).

In Study 1, we employed a reaction time paradigm to test the immediate behavioral consequences of presenting stop signals near palatable foods. Specifically, we tested our basic assumption that presenting palatable foods near stop signals would instantly inhibit chronic dieters' behavior. In Study 2 we moved beyond the immediate effects of stop signals on behavior by examining whether consistently presenting a particular palatable food near stop signals can even effect a more distal, but crucial outcome measure, i.e., chronic dieters' subsequent consumption of this food in an everyday life context.

Study 1

In Study 1 we tested whether presenting stop signals near palatable foods would instantly inhibit chronic dieters' unintentional impulses toward these foods. To test this, we presented participants with task-irrelevant images of palatable foods or control objects on a computer screen. Previous work has revealed that such task-irrelevant presentation of objects is sufficient to evoke impulses to obtain such objects when people are sensitive to the appetitive nature of such objects (i.e., an instance of unintentional elicitation of impulses; Veling & Aarts, in press-b). Because chronic dieters are more sensitive to the appetitive nature of palatable food cues than nondieters (as explained above), we expected such presentation to evoke impulses to obtain these objects for chronic dieters and not so much for nondieters. Superimposed over these images we presented go cues or no-go cues (i.e., the stop signals) that required a response, or withholding a response respectively (see Veling & Aarts, in press-b for this procedure). Importantly, participants were also instructed to respond as fast as possible to action probes that occasionally, and unpredictably, appeared after the object-cue combinations (i.e., an independent probe method; Anderson & Spellman, 1995). This task allowed us to measure whether behavior was temporarily put on a hold after each object type (palatable food vs. control) by cue type (go vs. no-go) combination.

We predicted that the no-go cues would inhibit impulses toward palatable foods in chronic dieters. As explained above, this inhibition of motor impulses toward palatable foods by the no-go cues should put behavior temporarily on hold, and hence be observable in a slow-down in responding to the action probes. Thus, we expected that chronic dieters would be slower to respond after presentation of palatable foods with no-go cues than after presentation of control objects with no-go cues. In contrast, previous work has shown that appetitive objects do not speed up responses to the action probes after presentation of go cues (Veling & Aarts, in press-b). Therefore, we did not expect a difference between action probe responses following palatable foods with go cues or control objects with go cues. In sum, we expected a three-way interaction between chronic dieting, cue type and object type such that action probe responses by chronic dieters would be inhibited after presentation of no-go cues with palatable foods.

Method

Participants and design

Study 1 included 38 undergraduates (all women; mean age = 21.21, SD = 3.37). Participants received a small payment for their participation. We employed a 2 (object type: palatable food vs. control objects) by 2 (cue type: go vs. no-go) within subjects design, and included chronic dieting as a continuous variable.

Stimuli

For the go/no-go task we selected 12 color pictures of palatable foods (i.e., potato chips, chocolate, cheese, 2 pictures of ice-cream, cookies, mars candy bar, pie, popcorn, cheese sandwich, French-fried potatoes, and pizza) comparable to those used in previous research on chronic dieting and impulsive responses (Papies et al., 2008; Papies, Stroebe, & Aarts, 2009). As control objects we used 12 neutral IAPS pictures depicting common objects and art (e.g., a light bulb, an empty mug).[1] Pictures are approximately 250 by 250 pixels in size and presented on a computer screen with a 800 by 600 resolution.

Concern for Dieting scale

To assess chronic dieting, participants were asked to fill out the Concern for Dieting subscale of the Revised Restraint scale after performing the go/no-go task (Herman & Polivy, 1980; Jansen, Oosterlaan, Merckelbach, & van den Hout, 1988). This subscale of the restraint scale has been recommended (i.e., over the scale as a whole and the Weight Fluctuation subscale) and used to specifically assess participants' chronic motivation to control their weight by dieting (e.g., Blanchard & Frost, 1983; Hofmann, Van Koningsbruggen, Stroebe, Ramanathan, & Aarts, 2010; Papies & Hamstra, 2010; Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008; van Strien, Breteler, & Ouwens, 2002; Wardle, 1986). The subscale assesses participants' motivation to restrain their eating by six items such as "How often are you dieting?" and "How conscious are you of what you are eating?". Higher scores reflect a stronger chronic dieting goal. We also asked participants how many minutes had past since their last food consumption.

Procedure

Participants received a modified version of a go/no-go task, and were asked to respond as accurately and quickly as possible to briefly presented cues that appeared on the computer screen in combination with other stimuli. Each trial consisted of two phases (see Fig. 1). First, participants were presented with pictures that were displayed in the middle of a computer screen, accompanied by either a go cue or no-go cue. The go/no-go cues were the letters "p" and "f". We counterbalanced instructions (e.g., "p" is the go cue and "f" the no-go cue) across participants. The go/no-go cues were displayed on the pictures in black font type (font size 12) against a white background, so that they were clearly visible. The presentation of a picture with a go or no-go cue lasted 500 ms. We expected inhibition to occur during presentation of a palatable food with a no-go cue, and hence this phase of each trial can be considered the inhibition induction phase (see Fig. 1).

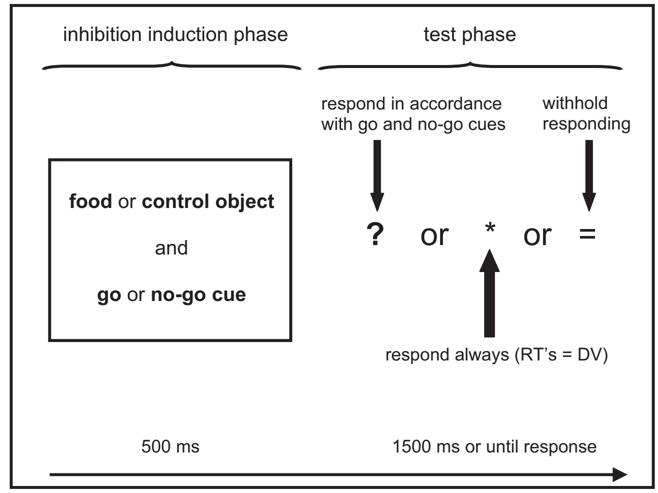

Fig. 1. Outline of a trial in Study 1. A food or control object was presented together with a go or no-go cue. Participants were asked to act in line with the go and no-go cues upon subsequent presentation of a question mark (2/3 of the trials). When an equal sign appeared they had to refrain from responding irrespective of the go and no-go cues (1/3 of the trials). Most importantly, when an asterisk appeared participants were instructed to always respond by pressing the space bar, irrespective of the initially presented go or no-go cues (1/3 of the trials). Reaction times to these action probes served as our dependent variable. RTs = reaction times. DV = dependent variable.

In the second phase of the trial, immediately after each picture-cue combination, a "?", or a "*", or a " = " appeared in blue font type (see Fig. 1). These signs were displayed in the center of the computer screen for either 1500 ms, or until the participant responded. In the case of a "?", participants were asked to respond in accordance with the cue: Press the space bar with the index finger of the right hand after presentation of a go cue and refrain from responding after presentation of a no-go cue. These filler trials were included to ensure that the go and no-go cues became associated with responding and withholding a response. However, when a "*" appeared participants were asked to always press the space bar, i.e. even when a no-go cue had been displayed on the picture. Thus, the earlier no-go signal was overruled on these trials. Reaction times on these action probe trials served as our dependent variable. In addition, when a " = " appeared participants were asked to always refrain from responding, i.e. even when a go cue had been displayed over a picture. This kind of filler trials only included to ensure that the probability of a no-go response was 50%. After a correct (non) response a green circle was presented, and after an erroneous (non) response a red cross was presented for 500 ms. The intertrial interval was 500 ms.

The go/no-go task consisted of five experimental blocks of 24 trials. Within each block, each object (i.e., palatable food or control) was presented once. In 50% of the trials a go cue was presented, and in 50% a no-go cue was presented. Selection of a specific object and cue was random with the constraints that a specific object (food or control), and cue type (go or no-go) was not presented more than four times in a row, and that food and control objects were equally often paired with each cue type. After each object-cue combination either a "?", or "*", or " = " appeared. The "?" was presented in 16 trials, the "*" in four trials and " = "also in four trials. These signs were randomly selected with the constraints that, for each stimulus type (palatable food or control), every six trials consisted of four "?" signs, one "*" sign and one " = " sign, and that the "?", "*", and " = " signs were equally often paired with each cue type (go or no-go). In total participants received 20 action probe trials, 5 for each object (i.e., arousing or control) – cue type (go or no-go) combination.

[1] The IAPS picture identification numbers are 7000, 7002, 7004, 7009, 7010, 7035, 7090, 7160, 7170, 7185, 7207, 7233.

Before starting the test blocks participants received a practice block including all trial types. Afterward, participants were debriefed and thanked for their participation. None of the participants reported any suspicion of the true nature of the study.

Results

Participants made few errors on the go/no-go task (3.4%). As in previous work (Veling & Aarts, in press-b), action probe trials with responses that were faster than 300 ms (1.4%), and omissions (1.6%) were removed, and we conducted analyses on log-transformed reaction times of the action probe trials.

We analyzed response latencies on action probe trials in the General Linear Model including the effects of object type (palatable food vs. control) and cue type (go vs. no-go) as within subjects factors and chronic dieting as a continuous factor. This analysis yielded a main effect of cue type, $F(1, 36) = 19.05$, $p < .01$, $\eta_p^2 = .35$, which indicated that participants were slower after presentation of no-go cues than after presentation of go cues. More importantly, this main effect was qualified by an interaction between object type and cue type, $F(1, 36) = 8.05$, $p < .01$, $\eta_p^2 = .18$. Participants were significantly slower to respond after presentation of palatable foods with no-go cues ($M = 604$; $SD = 138$) than after neutral control objects with no-go cues ($M = 565$; $SD = 104$), $F(1, 37) = 4.20$, $p < .05$, $\eta^2 = .10$. In contrast, there was no significant difference when the palatable foods had been paired with go cues ($M = 516$; $SD = 75$) compared to when control objects had been paired with go cues ($M = 526$; $SD = 82$), $F(1, 37) = 1.70$, $p = .20$, $\eta^2 = .04$.

Most importantly, the two-way interaction between object type and cue type was qualified by the predicted three-way interaction between object type, cue type, and chronic dieting, $F(1, 36) = 4.15$, $p < .05$, $\eta_p^2 = .10$ (see Fig. 2). Next, we examined the two two-way interactions between object type and cue type for participants with relative low chronic dieting scores (1 SD below the mean of the standardized chronic dieting score) and for participants with relative high chronic dieting scores (1 SD above the mean of the standardized chronic dieting score; see Aiken & West, 1991 for this regression analysis). With this estimation procedure we can test differences between mean reaction times to palatable food trials with no-go cues and control objects with no-go cues within low vs. high levels of chronic dieting separately without conducting a median split and while retaining all observations in the analysis (e.g., Irwin & McClelland, 2003; Royston, Altman, & Sauerbrei, 2006; see e.g. also Hofmann et al., 2010).

For the chronic dieters (1 SD above the mean standardized chronic dieting score) we observed a main effect for cue type $F(1, 36) = 6.85$, $p < .05$, $\eta_p^2 = .16$, but more importantly, the predicted interaction between cue type and object type was significant, $F(1, 36) = 11.85$, $p < .01$, $\eta_p^2 = .25$ (see right panel of Fig. 2). Consistent with our expectations, simple effect analyses revealed that chronic dieters were significantly slower to respond when palatable foods had been paired with no-go cues, than when control objects had been paired with no-go cues, $F(1, 36) = 6.30$, $p < .05$, $\eta^2 = .15$ (see gray bar on right panel of Fig. 2). There was no significant difference for chronic dieters when palatable food objects had been paired with go cues compared to when control objects had been paired with go cues, $F(1, 36) = 2.56$, $p = .12$, $\eta^2 = .07$.

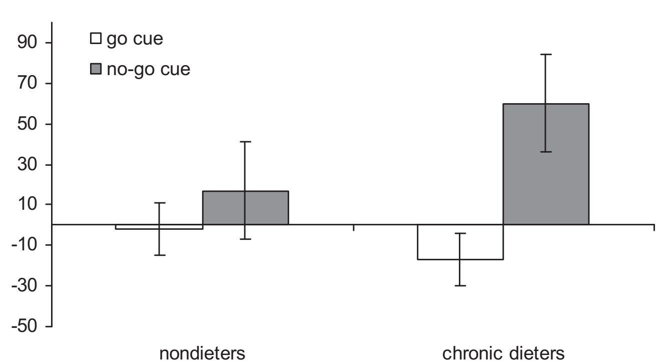

Fig. 2. Mean difference in reaction times in milliseconds on action probe trials between palatable foods and control objects as a function of cue type for nondieters and chronic dieters. Higher scores reflect slower responses after perception of palatable foods compared to control objects. Error bars = SE.

Although there was a tendency for nondieters (1 SD below the mean standardized chronic dieting score) to react slowest when no-go cues had been presented with palatable foods, there was merely a main effect for cue type $F(1, 36) = 12.34$, $p < .01$, $\eta_p^2 = .26$. Nondieters were slower to respond after no-go cues ($M = 589$; $SD = 111$) than after go cues ($M = 519$; $SD = 73$). However, action probe reaction times were not influenced by object type, $F < 1$, or an interaction between cue type and object type, $F < 1$ (see left panel of Fig. 2).

Additional analyses revealed that time since last food consumption was not related to the chronic dieting scale ($r = .01$, $p = .95$). Hence, the difference between chronic dieters and nondieters cannot be accounted for by differences in time since last food consumption (cf. Veling & Aarts, in press-b).

Discussion

The goal of Study 1 was to test whether stop signals can be used to inhibit chronic dieters' unintentional impulses toward palatable foods. Based on the notion that inhibition of impulses puts behavior temporarily on hold (Stinear et al., 2009; Veling & Aarts, in press-b), we tested whether chronic dieters would be slower to react to action probes after presentation of task-irrelevant palatable foods with stop signals. Consistent with our expectations, results indeed revealed that presentation of palatable foods with no-go cues caused slower responding to the action probes compared to presentation of control objects with no-go cues. Moreover, this disruptive effect of stop signals was particularly strong for chronic dieters, who have been shown to react more strongly to food cues than nondieters (e.g., Brunstrom et al., 2004; Fedoroff et al., 1997; Jansen & van den Hout, 1991; Klajner et al., 1981; Veenstra & de Jong, 2010). The stronger disruptive effect of stop signals among chronic dieters is in line with previous research showing that the inhibitory effect of stop signals on the motor system is adapted to the strength of the initially evoked impulse (Nakata et al., 2006; Stinear et al., 2009). Thus, stop signals appear to instigate a dynamic braking mechanism that instantly inhibits chronic dieters' behavior upon perception of palatable foods.

Because our aim was to examine the immediate behavioral consequences of presenting stop signals near palatable foods, we measured a behavioral correlate (i.e. slowed responses) of the outcome of a covert inhibitory process (i.e., motor inhibition) rather than motor inhibition directly (note that the latter cannot be assessed directly with behavioral measures). The advantage of such an indirect measurement approach is that the effect of presenting stop signals near palatable foods on overt behavior, i.e., putting behavior temporarily on hold, can be observed. A limitation of the current indirect measurement method, however, is that the occurrence of motor inhibition cannot be unambiguously demonstrated. Future work may further examine the immediate effects of presenting stop signals near palatable foods, and conduct neurological measurements during the presentation of stop cues and palatable foods to assess the occurrence of motor inhibition more directly (Stinear et al., 2009). In any case, Study 1 reveals that presenting stop signals near palatable foods inhibits chronic dieters' subsequent overt behavior.

The results of Study 1 raise the important question of how stop signals may be used to improve chronic dieters' self-control in tempting everyday situations. Specifically, when stop signals are not present in the environment of palatable foods, e.g. outside the psychological laboratory, they cannot inhibit any impulses toward tempting foods. Hence, an important challenge is to develop a way that uses stop signals to improve dieting behavior in circumstances where stop signals are not physically present. We addressed this important topic in Study 2.

Moreover, a limitation of Study 1 is that we did not assess body weight. As body weight has been found to correlate with chronic dieting status (e.g., Klesges et al., 1992; Lowe, 1984; Ruderman, 1986; Snoek, van Strien, Janssens, & Engels, 2008; Stice et al., 1999), it is hence currently unclear whether the key variable responsible for the effects of stop signals in Study 1 could be body weight instead of, or in addition to, chronic dieting status. Therefore, we measured body weight in addition to chronic dieting in Study 2.

Study 2

In Study 2 we examined whether stop signals can be used to control chronic dieters' actual consumption of palatable foods in an everyday life context. One way of how this may be accomplished is by a short intervention procedure in which palatable foods are consistently accompanied by stop signals. Repeated inhibition toward appetitive objects has been shown to diminish the impulse-evoking potential of these objects when they are subsequently encountered (Veling & Aarts, 2009), and should therefore reduce occurrence of behavior toward such objects (e.g., Hofmann et al., 2008; Strack & Deutsch, 2004). First evidence from one recent study indeed suggests repeated presentation of stop signals near palatable foods can be effective in modifying subsequent responses toward palatable foods.

Specifically, in this study (Houben & Jansen, 2011), palatable foods were consistently associated with stop signals (i.e., no-go cues in a go/no-go task) in the no-go condition. In the control condition no such association was established. Next, immediately after the manipulation, consumption of the food was measured in a taste test. Results revealed that participants in the no-go condition consumed less of the food that had been presented with no-go cues compared to participants in the control condition. Importantly, this effect occurred particularly for chronic dieters. Bearing in mind that chronic dieters are motivated to restrict their intake of palatable foods (e.g., Chernyak & Lowe, 2010), this finding is a first indication that stop signals may be helpful in improving chronic dieters' dieting behavior in response to palatable foods.

In Study 2 we aimed to further test the potential of stop signals to improve chronic dieters' self-control toward palatable foods. In particular, we were interested to test whether an intervention procedure that presents stop signals consistently near a particular palatable food not only affects consumption behavior in a taste test in the psychological laboratory immediately following this intervention, but can even influence consumption behavior in less controlled circumstances in everyday life. Considering that dieting behavior generally takes place in the busy and complex environment outside the psychological laboratory (e.g., Stice et al., 2004; Stroebe, 2008), such an examination would naturally be an important step further to evaluate the potential of stop signals as a psychological intervention tool to facilitate dieting behavior. Furthermore, we also examined the effectiveness of stop signals as a function of Body Mass Index (BMI). We were interested to investigate whether stop signals would only affect those individuals that have a dieting goal, or whether stop signals can also affect individuals that are, like chronic dieters, sensitive to the appetitive nature of food cues (i.e., participants with relatively high BMI; see e.g., Batterink, Yokum, & Stice, 2010; Bruce et al., 2010; Stice, Spoor, Bohon, Veldhuizen, & Small, 2008), independent of dieting goals.

In Study 2, we first presented participants with a task in which a particular palatable food was consistently presented with stop signals (no-go condition), or not (control condition). Next, participants received a candy bag containing the palatable food to take home with them, and they were informed that they were free to consume as much or as little of the food as they liked. After one day participants returned to the laboratory with the candy bag, so that we could assess the amount of food consumed (see also Stirling & Yeomans, 2004). Based on Study 1, we expected that chronic dieters in the no-go condition would benefit most from the initial presentation of palatable foods with stop signals, and hence we expected reduced consumption of chronic dieters' consumption of the food in the no-go condition.

Method

Participants and design

Study 2 included 46 undergraduates (28 women). This sample size was based on previous research (Houben & Jansen, 2011). Participants received a small payment for their participation. Participants were randomly assigned to the no-go condition or control condition (between-subjects), and we included chronic dieting as a continuous factor.

Stimuli

As palatable food we selected a kind of sweets (soft sweet liquorice) that are common and very popular in the Netherlands (product name: Kokindjes). This type of candy has been used previously to study eating behavior in chronic dieters and non-dieters (Jansen et al., 2009), and is considered a potential source of overeating. For instance, at their website, the Netherlands Nutrition Centre explicitly advices hiding this candy from sight to avoid overeating (Voedingcentrum, 2011). Each sweet weighs about 3 g, and they contain 337.8 kcal per 100 g. At the start of the study, each participant received a pink, partly transparent bag containing 150 g sweets (i.e., packaged similarly as they can be bought in grocery stores). For the manipulation we used three different pictures of the sweets: 1 picture of the closed candy bag, 1 picture of the sweets in an opened candy bag, and 1 picture of the sweets without the bag. All pictures contained a white background. Furthermore, we selected 5 pictures of everyday objects (i.e., a candle, a vase, a pen, a light bulb, and a bottle of soap) that served as fillers during the manipulation.

Manipulation

Participants were informed that we were interested in studying attentional processes in the presence of everyday objects. Participants read that task-irrelevant objects of daily life would be presented in the middle of the computer screen for 1500 ms accompanied by either the letter A or L. The letters A or L were presented randomly at one of four possible locations near one of the corners of the objects, and remained visible during the presentation of the objects (i.e., for 1500 ms). The letters were presented in black font on a white background so that they were clearly visible.

After each object-letter combination, a blue question mark would appear for 1000 ms. Depending on the previously presented letter, participants were instructed to respond as fast and accurately as possible during presentation of this question mark.

Participants in the no-go condition learned that the task was to respond by pressing the space bar when an A (or L counterbalanced across participants) had been presented over the object, and withhold a response when a L (or A) had been presented. Accordingly, in the no-go condition the letters A and L functioned as go cues and no-go cues. In the control condition the instruction was to press the A button when an A had been presented and press the button L when an L had been presented on a QWERTY keyboard. Participants were requested to react as fast and accurately as possible. Accuracy feedback was presented after each trial (i.e., a green circle was presented after correct responses and a red cross after incorrect responses).

The task consisted of 12 blocks of 6 trials. Within each block, one picture of the sweets was presented, and the five pictures of the filler objects. In the no-go condition, the sweets were always accompanied by a no-go cue, and the filler objects with either no-go cues (two trials) or go cues (three trials). Thus within each block and across the task the probability of responding in the no-go condition was 50%. In the control condition the objects were presented with the same letters as in the no-go condition. Thus, in both conditions the task involved the categorization of letters that were presented over task-irrelevant objects. The crucial difference between conditions was that this categorization involved withholding a response toward the sweets in the no-go condition, but not in the control condition.

Concern for Dieting scale

As in Study 1, participants were asked to fill out the Concern for Dieting (CD) subscale of the Revised Restraint scale (Herman & Polivy, 1980; Jansen et al., 1988; Cronbach's $\alpha = .61$). We also assessed participants' weight and height to calculate their Body Mass Index (BMI; kg/m^2).

Procedure

Before starting the study participants were informed that the study would involve tasting sweets, and that they would be requested to return to the laboratory the next day. After signing informed consent participants started with the first part of the study. Participants learned that the study examined various aspects of consumer behavior such as attention for consumer objects and tasting foods. Then, participants received a candy bag containing 150 g of sweets. They were told that the first task was to take one of the sweets out of the bag and taste it. The experimenter remained present at this stage to ensure that only one of the sweets was taken out of the candy bag. After consuming the sweet participants were asked to rate the sweets on a number of taste dimensions (e.g., sweetness, saltiness). The primary goal of this first task was to familiarize participants with the candy bag, and to ensure that participants would feel free to consume sweets from the bag after finishing the first part of the study. Moreover, this tasting task was used to distract participants from the true purpose of the study, i.e., assessing the amount of sweets consumed after leaving the laboratory.

After this first task participants received the letter categorization task (i.e., the manipulation). Afterward, participants were asked to indicate how often they had seen a candle and a vase during the task. This question was merely asked to further distract participants' attention from the true purpose of the study. Next, participants read that they were approaching the end of the first part of the study, and that they could take the candy bag home with them. It was emphasized that participants could consume as little or as much from these sweets as they liked. Moreover, they read that they should return with the candy bag one day later to answer some additional questions regarding the sweets. Finally, participants made an appointment with the experimenter to return to the laboratory the next day and left the room.

When participants returned the next day for the second part of the study they were first asked to hand over the candy bag to the experimenter. Next, they answered some questions on a computer screen. They filled out the Concern for Dieting scale, answered some demographic questions, and were probed for awareness with regard to the purpose of the study. Specifically, participants were asked i) whether they could indicate the goal of the study, ii) whether they had any ideas about the relation between the computerized task in the first phase of the study and the fact that they received a candy bag, and iii) whether they thought that the computerized task in the first phase of the experiment had affected their consumption of sweets. Answers to these questions indicated that participants were unaware of any effects that the manipulation may have had on their behavior. Thus, any effects of the manipulation are likely not caused by participants' theories about the effect of the manipulation on consumption behavior. The experimenter weighted the candy bag, and the amount of sweets consumed (in grams) served as the dependent variable. Finally, participants were debriefed and thanked for their participation.

Results

There were no significant differences between the no-go and control conditions with regard to age ($M_{\text{no-go}} = 21.27$, SD = 2.81; $M_{\text{control}} = 21.04$, SD = 2.94), percentage of women (59.1% in the no-go condition vs. 62.5% in the control condition), BMI ($M_{\text{no-go}} = 21.11$, SD = 2.54; $M_{\text{control}} = 21.98$, SD = 2.70), or chronic dieting ($M_{\text{no-go}} = 4.91$, SD = 2.76; $M_{\text{control}} = 5.50$, SD = 2.52; all Fs < 1). Furthermore, time (in hours) between participating in the first session and second session did also not differ between the no-go ($M = 21.77$, SD = 2.07) and the control conditions ($M = 22.00$, SD = 1.84), $F < 1$. Moreover, percentage of correct responses of the letter categorization task in the no-go condition ($M = 97$, SD = 4.05) did not differ from the percentage of correct responses in the control condition ($M = 99$, SD = 2.01), $F(1, 44) = 2.25$, $p = .14$, $\eta_p^2 = .05$. Initial inspection of the consumption of sweets revealed that three participants did not consume any sweets from the candy bag (two in the control condition). We included these participants in the analyses, but excluding them from the sample did not alter the pattern or significance of the results reported below. We obtained no gender effects (Fs < 1 for the main effect and interactions), and this factor was therefore dropped from the analyses.

The amount of sweets consumed (in grams) was analyzed in the General Linear Model with condition (control vs. no-go) as between-subjects factor and chronic dieting as continuous factor. The only significant effect that emerged from this analysis was the predicted interaction between condition and chronic dieting, $F(1, 42) = 6.01$, $p < .02$, $\eta_p^2 = .13$. To investigate the nature of this interaction, we examined the amount of sweets consumed by chronic dieters (i.e., 1 SD above the mean of the standardized chronic dieting score; see Aiken & West, 1991) and nondieters (1 SD below the mean of the standardized chronic dieting score) separately. As illustrated by Fig. 3, chronic dieters consumed significantly less sweets when the sweets had been presented with stop signals (i.e., in the no-go condition) compared to when the sweets had not been presented with stop signals (i.e., in the control condition), $F(1, 42) = 6.25$, $p < .02$, $\eta_p^2 = .13$. Nondieters' eating behavior was unaffected by condition, $F < 1$, *ns*. Moreover, additional regression analyses showed that chronic dieting was negatively and significantly related to consumption in the no-go condition, $\beta = .-52$, $t(21) = -2.75$, $p < .02$, whereas chronic dieting was positively but not significantly related to consumption in the control condition, $\beta = .19$, $t(23) = .91$, $p = .38$. Thus, chronic dieters in the no-go condition consumed less compared to both

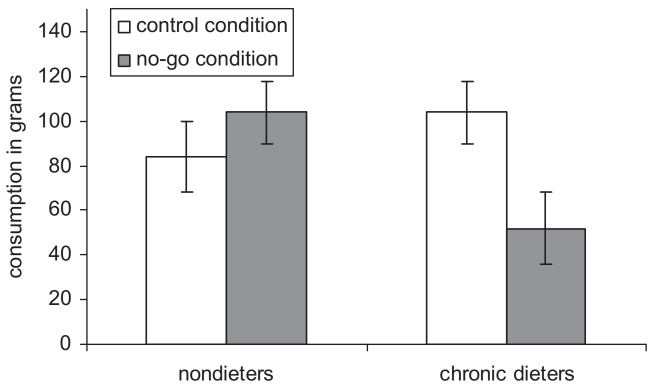

Fig. 3. Mean amount of sweets consumed by chronic dieters and nondieters in the control and no-go conditions. Error bars = SE.

chronic dieters in the control condition and nondieters in the no-go condition.

Additional analyses

Consistent with previous studies (e.g., Klesges et al., 1992; Lowe, 1984; Ruderman, 1986; Snoek et al., 2008; Stice et al., 1999), chronic dieting was correlated with BMI in the present sample ($r = .45$). This relation may reflect the fact that overweight individuals are more likely than normal weight individuals to pursue repeated dieting attempts, and hence more likely to become chronic dieters (Lowe, 1984; Snoek et al., 2008), or that chronic dieters are at a higher risk to gain weight compared to nondieters (e.g., Klesges et al., 1992; Stice et al., 1999, 2005). However, controlling for BMI in the present analyses left the pattern of results and the interaction between condition and chronic dieting essentially unchanged (i.e., interaction effect when controlling for BMI, $F(1, 41) = 5.16$, $p < .03$, $\eta_p^2 = .11$). Furthermore, a GLM with condition as between-subjects factor and BMI and chronic dieting as continuous predictors revealed that the three-way interaction between chronic dieting, BMI, and condition was not significant, $F < 1$.

Next, we conducted a General Linear Model with condition (control vs. no-go) as between-subjects factor and BMI as continuous factor while controlling for chronic dieting. This analyses yielded a marginally significant interaction between condition and BMI, $F(1, 41) = 3.15$, $p = .08$, $\eta_p^2 = .07$. Results showed a trend indicating that relatively high BMI participants (1 SD above the mean standardized BMI score) consumed less sweets (in grams) in the no-go condition ($M = 71.94$, SD = 17.80) than in the control condition ($M = 115.30$, SD = 14.75), $F(1, 41) = 3.67$, $p = .06$, $\eta_p^2 = .08$. No difference in eating behavior was found between the no-go condition ($M = 84.61$, SD = 15.01) and control condition ($M = 71.31$, SD = 16.88) among relatively low BMI participants (1 SD below the mean the mean standardized BMI score), $F < 1$, *ns*. Additional regression analyses revealed that BMI was negatively but not significantly related to eating behavior within the no-go condition ($\beta = -.20.$, $t(21) = -.90$, $p = .38$), and positively but not significantly related to consumption in the control condition ($\beta = .26.$, $t(23) = 1.28$, $p = .22$). Thus, it seems that, if anything, no-go cues reduced consumption of palatable foods in relatively high BMI participants of the current sample.

Discussion

Results of Study 2 reveal that consistently presenting a particular palatable food near stop signals subsequently reduced chronic dieters' consumption of this food. Stop signals did not have this effect among nondieters. This result converges well with the findings of Study 1, and shows that stop signals not only put chronic dieters' behavior toward palatable foods temporarily on hold, but also improve self-control toward palatable foods in an everyday life context. That is, the stop signal task ensured that chronic dieters acted more in line with their chronic motivation to restrain their food intake across a one day period. The finding that chronic dieters reduced their consumption in the no-go condition replicates a recent study that showed effects of stop signals on consumption behavior of chronic dieters in a taste test in the laboratory (Houben & Jansen, 2011), and extends this previous finding by showing that the effects of stop signals can even be observed in less well controlled circumstances where participants consume food in an everyday life context over a mean duration of more than 20 h. The fact that consistent effects of stop signals are observed across different laboratories and different settings provides encouraging evidence that stop signals provide a promising psychological intervention tool to improve chronic dieters' control over their food consumption.

Dieters in the control condition did not significantly consume more food than nondieters. Although chronic dieters have been shown to eat more than nondieters in the laboratory (e.g., Fedoroff et al., 1997; Jansen et al., 2009; Jansen & van den Hout, 1991; Rogers & Hill, 1989) results of Study 2 are consistent with research that has found that chronic dieters often eat just as much as nondieters in the natural environment (e.g., Stice et al., 2004). Importantly, chronic dieters are motivated to restrict their eating more than nondieters (e.g., Chernyak & Lowe, 2010), and indeed reduce their food intake below the level of nondieters when they are explicitly reminded about their dieting goal (Anschutz et al., 2008; Papies & Hamstra, 2010; Ward & Mann, 2000; see Stroebe et al., 2008 for a model). From this perspective, then, chronic dieters' eating behavior in the control condition can be considered an instance of unsuccessful dieting behavior, and the stop signals ensured that chronic dieters actually restricted their food intake. Moreover, the reduced food consumption by chronic dieters compared to nondieters within the no-go condition is also consistent with the notion that stop signals facilitated behavior to act in line with participants' chronic dieting goal.

Results of Study 2 also revealed a trend suggesting that stop signals are effective in reducing food consumption for participants with a relatively high BMI. What is particularly intriguing about this finding is that this effect was found to be independent of participants' chronic dieting goal. Accordingly, stop signals are not only helpful for chronic dieters to facilitate acting in line with their dieting goal, but also appear effective in reducing consumption of food among nondieters that are, like chronic dieters, sensitive to the appetitive nature of food cues (i.e., participants with a relatively high BMI). This finding thus suggests that a goal to restrict one's food consumption is not necessary to reduce consumption of palatable foods via stop signals. Future research with a larger sample size may test whether this interesting pattern can be replicated, and whether the interaction between stop signals and BMI is indeed independent of chronic dieting status. For now, we can conclude that stop signals facilitated dieting behavior in a normal weight sample of chronic dieters, which may ultimately prevent these dieters from becoming overweight (see e.g., Klesges et al., 1992; Stice et al., 1999, 2005).

General discussion

Dieting has been found to be a rather ineffective weight maintenance and weight reduction strategy (Elfhag & Rössner, 2005; Jeffery et al., 2000; Mann et al., 2007). With regard to chronic dieting, prospective studies have shown that chronic dieters often gain more weight than nondieters (e.g., Klesges et al., 1992; Stice et al., 1999, 2005). Current approaches to self-control suggest that unintentional impulses toward palatable foods, a proximal determinant of eating behavior, may contribute to the difficulty to restrict food intake when dieting (e.g., Baumeister & Heatherton, 1996; Hofmann et al., 2008; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). Indeed, it has been shown that individual differences in the ability to inhibit one's impulsive responses in general and food in particular, are linked to distal outcome variables such as body weight (Batterink et al., 2010; Nederkoorn et al., 2006, 2007, 2010). However, to date there has been only limited attention to the question of how unintentional impulses to palatable foods can be modified to change behavior toward palatable foods (e.g., Guerrieri, Nederkoorn, Schrooten, Martijn, & Jansen, 2009; Houben, 2011; Houben & Jansen, 2011; Rotenberg et al., 2005; Veling, Aarts, & Stroebe, 2011).

The present work examined the potential of behavioral stop signals to directly inhibit unintentionally evoked impulses toward palatable foods, and tested whether stop signals can even improve chronic dieters' control over their food consumption. In Study 1 we focused on the question whether presentation of a stop signal near palatable foods would instantly inhibit chronic dieters' impulses to obtain these foods. Results of this study showed that presentation of stop signals near palatable foods inhibited chronic dieters' subsequent responding, suggesting inhibition of the impulse. Although a few studies have proposed such a motor inhibition mechanism as a result of presenting no-go cues near palatable foods, these studies did not attempt to measure this motor inhibition (e.g., Houben, 2011; Houben & Jansen, 2011; see also Veling & Aarts, 2009). The present research thus provides novel empirical evidence by revealing that stop signals can be used to instantly inhibit chronic dieters' behavior when they are exposed to palatable foods.

In Study 2, we moved an important step further by examining whether stop signals would not only inhibit impulses to tempting foods immediately, but would also inhibit responses to foods in an everyday life context where the stop signals were no longer physically present. Results of Study 2 revealed that an intervention that consistently presented stop signals near palatable foods reduced chronic dieters' consumption of food over a one day period. These results are particularly encouraging considering that the intervention task we used only toke a couple of minutes of participants'' time, was relatively effortless to perform, and nevertheless affected consumption outside the psychological laboratory.

An interesting fundamental question raised by the present findings is how consistently inhibiting a response toward a palatable food can subsequently improve chronic dieters' control of consumption of this food. The converging results of Studies 1 and 2 provide a preliminary answer. Specifically, Study 1 revealed that stop signals instantly inhibit impulses toward foods for chronic dieters, but not for nondieters. Accordingly, the repeated presentation of stop signals and palatable food in Study 2 may have repeatedly instigated inhibition toward this food in chronic dieters, but not in nondieters. Such repeated inhibition toward a particular palatable food can create an association between the percept of this food and an inhibition tag, so that mere perception of the food instantly reinstates the inhibition (Veling & Aarts, 2009; Verbruggen & Logan, 2008). As a result, perception of the palatable food is then sufficient to inhibit behavior of chronic dieters, and improve their self-control. In other words, the stop signals in the no-go condition may have prevented the unintentional impulse toward the food to overtly materialize in chronic dieters, and hence reduced likelihood of consumption of this food by chronic dieters. This account can explain the fact that the stop signal intervention affected chronic dieters' behavior, but did not affect consumption behavior of nondieters.

The stop signal method employed in the present research has two features that render it particularly appealing to be used as a tool to improve regulation of eating behavior in environments that contain palatable foods. First, stop signals should produce stronger inhibitory effects as impulses by palatable foods are evoked stronger. Hence, stop signals should be particularly effective for chronic dieters who experience the strongest difficulty with restricting their food consumption as a result of impulses that are evoked by palatable foods. Second, stop signals can be used to restrict eating behavior even when these signals are no longer physically present. Hence, this method of consistently presenting palatable foods with stop signals may be used to overcome problems with self-control toward these foods that stem from difficulties in recruiting inhibitory control in response to these foods in daily life (e.g., Batterink et al., 2010; Nederkoorn et al., 2007, 2010).

At the same time, however, it should be emphasized that the current study should be viewed as part of a novel approach to facilitate chronic dieters' restriction of food consumption (see also Houben & Jansen, 2011), i.e., by focusing on modifying chronic dieters' immediate responses to foods. As a result, a number of theoretical and practical questions remain to be answered before this approach can be recommended as a clinical intervention to improve chronic dieters' restriction of food consumption. First, it would be important to test whether effects of a single no-go intervention will last beyond one day, and whether repeated interventions are needed to boost and improve dieting behavior over longer time frames. Observing effects of stop signals under more complex circumstances, such as longer time intervals, may require larger samples than we used.

Second, it is currently unclear whether chronic dieters in clinical populations (e.g., chronic dieters that receive treatment for obesity), would benefit from stop signals in the same way as chronic dieters in our sample did. Furthermore, results of Study 2 suggested that stop signals may not only be used to facilitate restriction of food consumption in chronic dieters, but may also be used to reduce food consumption in other populations (e.g., participants with relatively high BMI). Future studies are needed to further examine the effects of stop signals among participants with different levels of BMI. Finally, it would be interesting to examine whether particular subgroups within chronic dieters benefit most from the use of stop signals in controlling their eating behavior (e.g., Jansen et al., 2009).

In sum, chronic dieters have been shown to consume just as much, or even more calories than nondieters (e.g., Fedoroff et al., 1997; Jansen & van den Hout, 1991; Papies & Hamstra, 2010; Stice et al., 2004; Stirling & Yeomans, 2004), and normal weight chronic dieters are at risk of becoming overweight (e.g., Klesges et al., 1992; Stice et al., 1999, 2005). We examined whether chronic dieters' restriction of food intake could become more successful by modifying chronic dieters' responses toward palatable foods. We have examined stop signals as a means to inhibit chronic dieters' immediate responses toward palatable foods, and we have applied stop signals to reduce chronic dieters' consumption of food in an everyday life context. Future work may further examine how a stop signal intervention can best be implemented to improve dieting behavior in environments where palatable foods are very visible and easily accessible.

References

Anderson, M. C., & Spellman, B. A. (1995). On the status of inhibitory mechanisms in cognition: memory retrieval as a model case. *Psychological Review, 102*, 68–100.

Anschutz, D. J., Van Strien, T., & Engels, R. C. M. E. (2008). Exposure to slim images in mass media: television commercials as reminders of restriction in restrained eaters. *Health Psychology, 27*, 401–408.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications, Inc.

Batterink, L., Yokum, S., & Stice, E. (2010). Body mass correlates inversely with inhibitory control in response to food among adolescent girls: an fMRI study. *Neuroimage, 52*, 1696–1703.
Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: an overview. *Psychological Inquiry, 7*, 1–15.
Blanchard, F. A., & Frost, R. O. (1983). Two factors of restraint: concern for dieting and weight fluctuation. *Behaviour Research and Therapy, 21*, 259–267.
Bruce, A. S., Holsen, L. M., Chambers, R. J., Martin, L. E., Brooks, W. M., Zarcone, J. R., et al. (2010). Obese children show hyperactivation to food pictures in brain networks linked to motivation, reward and cognitive control. *International Journal of Obesity, 32*, 1494–1500.
Brunstrom, J. M., Yates, H. M., & Witcomb, G. L. (2004). Dietary restraint and heightened reactivity to food. *Physiology and Behavior, 81*, 85–90.
Chernyak, Y., & Lowe, M. R. (2010). Motivations for dieting: drive for thinness is different from drive for objective thinness. *Journal of Abnormal Psychology, 119*, 276–281.
Collins, J. E. (1978). Effects of restraint, monitoring, and stimulus salience on eating behavior. *Addictive Behaviors, 3*, 197–204.
Coxon, J. P., Stinear, C. M., & Byblow, W. D. (2009). Stop and go: the neural basis of selective movement prevention. *Journal of Cognitive Neuroscience, 21*(6), 1193–1203.
Custers, R., & Aarts, H. (2010). The unconscious will: how the pursuit of goals operates outside of conscious awareness. *Science, 329*, 47–50.
Elfhag, K., & Rössner, S. (2005). Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. *Obesity Reviews, 6*, 67–85.
Fedoroff, I. C., Polivy, J., & Herman, C. P. (1997). The effect of pre-exposure to food cues on eating behaviour of restrained and unrestrained eaters. *Appetite, 28*, 33–47.
Fedoroff, I. C., Polivy, J., & Herman, C. P. (2003). The specificity of restrained versus nondieters' responses to food cues: general desire to eat, or craving for the cued food? *Appetite, 41*, 7–13.
Gorman, B. S., & Allison, D. B. (1995). Measures of restrained eating. In D. B. Allison (Ed.), *Handbook of assessment methods for eating behaviors and weight related problems: Measures, theory, and research* (pp. 149–184). Thousand Oaks, CA: Sage.
Guerrieri, R., Nederkoorn, C., Schrooten, M., Martijn, C., & Jansen, A. (2009). Inducing impulsivity leads restrained eaters into overeating, whereas current dieters stick to their diet. *Appetite, 53*, 93–100.
Harvey, K., Kemps, E., & Tiggemann, M. (2005). The nature of imagery processes underlying food cravings. *British Journal of Health Psychology, 10*, 49–56.
Herman, C. P., & Polivy, J. (1980). Restrained eating. In A. J. Stunkard (Ed.), *Obesity* (pp. 208–225). Philadelphia: Saunders.
Hill, J. O., & Peters, J. C. (1998). Environmental contributions to the obesity epidemic. *Science, 280*, 1371–1374.
Hofmann, W., & Friese, M. (2008). Impulses got the better of me: alcohol moderates the influence of the impulsive vs. reflective system on eating behavior. *Journal of Abnormal Psychology, 117*, 420–427.
Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: a theoretical framework and empirical review. *Health Psychology Review, 2*, 111–137.
Hofmann, W., Van Koningsbruggen, G. M., Stroebe, W., Ramanathan, S., & Aarts, H. (2010). As pleasure unfolds: hedonic responses to tempting food. *Psychological Science, 21*, 1863–1870.
Houben, K. (2011). Overcoming the urge to splurge: the role of inhibitory control in eating behavior. *Journal of Behavior Therapy and Experimental Psychiatry, 42*, 384–388.
Houben, K., & Jansen, A. (2011). Training inhibitory control: a recipe for resisting sweet temptations. *Appetite, 56*, 345–349.
Irwin, J. R., & McClelland, G. H. (2003). Negative consequences of dichotomizing continuous predictor variables. *Journal of Marketing Research, 40*, 366–371.
Jansen, A., Nederkoorn, C., van Baak, L., Keirse, C., Guerrieri, R., & Havermans, R. (2009). High-restrained eaters only overeat when they are also impulsive. *Behaviour Research and Therapy, 47*, 105–110.
Jansen, A., Oosterlaan, J., Merckelbach, H., & van den Hout, M. A. (1988). Nonregulation of food intake in restrained, emotional, and external eaters. *Journal of Psychopathology and Behavioral Assessment, 10*, 345–354.
Jansen, A., & van den Hout, M. (1991). On being led into temptation: "counterregulation" of dieters after smelling a "preload". *Addictive Behaviors, 16*, 247–253.
Jeffery, R. W., Epstein, L. H., Wilson, G. T., Drewnowski, A., Stunkard, A. J., & Wing, R. R. (2000). Long-term maintenance of weight loss: current status. *Health Psychology, 19*, 5–16.
Klajner, F., Herman, C. P., Polivy, J., & Chhabra, R. (1981). Human obesity, dieting, and anticipatory salivation to food. *Physiology & Behavior, 27*, 195–198.
Klesges, R. C., Isbell, T. R., & Klesges, L. M. (1992). Relationship between restraint, energy intake, physical activity, and body weight: a prospective analysis. *Journal of Abnormal Psychology, 101*, 668–674.
Krieglmeyer, R., Deutsch, R., De Houwer, J., & De Raedt, R. (2010). Being moved: valence activates approach–avoidance behavior independent of evaluation and approach–avoidance intentions. *Psychological Science, 21*, 607–614.
Lowe, M. R. (1984). Dietary concern, weight fluctuation and weight status: further explorations of the restraint scale. *Behaviour Research and Therapy, 22*, 243–248.
Mann, T., Tomiyama, A. J., Westling, E., Lew, A. M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: diets are not the answer. *American Psychologist, 62*, 220–233.
Metcalfe, J., & Mischel, W. (1999). A hot/cool system analysis of delay of gratification: dynamics of willpower. *Psychological Review, 106*, 3–19.
Nakata, H., Inui, K., Wasaka, T., Tamura, Y., Akatsuka, K., Kida, T., et al. (2006). Higher anticipated force required a stronger inhibitory process in go/nogo tasks. *Clinical Neurophysiology, 117*, 1669–1676.
Nederkoorn, C., Braet, C., Van Eijs, Y., Tanghe, A., & Jansen, A. (2006). Why obese children cannot resist food: the role of impulsivity. *Eating Behaviors, 7*, 315–322.
Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health Psychology, 29*, 389–394.
Nederkoorn, C., Jansen, E., Mulkens, S., & Jansen, A. (2007). Impulsivity predicts treatment outcome in obese children. *Behaviour Research and Therapy, 45*, 1071–1075.
Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behavior: enhancing self-regulation by environmental cues. *Health Psychology, 29*, 384–388.
Papies, E. K., Stroebe, W., & Aarts, H. (2007). Pleasure in the mind: restrained eating and spontaneous hedonic thoughts about food. *Journal of Experimental Social Psychology, 43*, 810–817.
Papies, E. K., Stroebe, W., & Aarts, H. (2008). The allure of forbidden food: on the role of attention in self-regulation. *Journal of Experimental Social Psychology, 44*, 1283–1292.
Papies, E. K., Stroebe, W., & Aarts, H. (2009). Who likes it more? Restrained eaters' implicit attitudes toward food. *Appetite, 53*, 279–287.
Rogers, P. J., & Hill, A. J. (1989). Breakdown of dietary restraint following mere exposure to food stimuli: interrelationships between restraint, hunger, salivation, and food intake. *Addictive Behaviors, 14*, 387–397.
Rotenberg, K. J., Lancaster, C., Marsden, J., Pryce, S., Williams, J., & Lattimore, P. (2005). Effects of priming thoughts about control on anxiety and food intake as moderated by dietary restraint. *Appetite, 44*, 235–241.
Royston, P., Altman, D. G., & Sauerbrei, W. (2006). Dichotomizing continuous predictors in multiple regression: a bad idea. *Statistics in Medicine, 25*, 127–141.
Ruderman, A. J. (1986). Dietary restraint: a theoretical and empirical review. *Psychological Bulletin, 99*, 247–262.
Seibt, B., Häfner, M., & Deutsch, R. (2007). Prepared to eat: how immediate affective and motivational responses to food cues are influenced by food deprivation. *European Journal of Social Psychology, 37*, 359–379.
Snoek, H. M., van Strien, T., Janssens, J. M. A. M., & Engels, R. C. M. E. (2008). Restrained eating and BMI: a longitudinal study among adolescents. *Health Psychology, 27*, 753–759.
Stice, E., Cameron, R. P., Killen, J. D., Hayward, C., & Taylor, C. B. (1999). Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *Journal of Consulting & Clinical Psychology, 67*, 967–974.
Stice, E., Fisher, M., & Lowe, M. R. (2004). Are dietary restraint scales valid measures of acute dietary restriction? Unobtrusive observational data suggest not. *Psychological Assessment, 16*, 51–59.
Stice, E., Presnell, K., Shaw, H., & Rohde, P. (2005). Psychological and behavioral risk factors for onset of obesity in adolescent girls: a prospective study. *Journal of Consulting and Clinical Psychology, 73*, 195–202.
Stice, E., Spoor, S., Bohon, C., Veldhuizen, M., & Small, D. (2008). Relation of reward from food intake and anticipated intake to obesity: a functional magnetic resonance imaging study. *Journal of Abnormal Psychology, 117*, 924–935.
Stinear, C. M., Coxon, J. P., & Byblow, W. D. (2009). Primary motor cortex and movement prevention: where stop meets go. *Neuroscience and Biobehavioural Reviews, 33*, 662–673.
Stirling, L. J., & Yeomans, M. R. (2004). Effect of exposure to a forbidden food on eating in restrained and unrestrained women. *International Journal of Eating Disorders, 35*, 59–68.
Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*, 220–247.
Stroebe, W. (2008). *Dieting, overweight and obesity: Self-regulation in a food-rich environment*. Washington, DC: American Psychological Association.
Stroebe, W., Mensink, W., Aarts, H., Schut, H., & Kruglanski, A. W. (2008). Why dieters fail: testing the goal conflict model of eating. *Journal of Experimental Social Psychology, 44*, 26–36.
van Strien, T., Breteler, M. H. M., & Ouwens, M. A. (2002). Restraint scale, its subscales concern for dieting and weight fluctuation. *Personality and Individual Differences, 33*, 791–802.
Veenstra, E. M., & de Jong, P. J. (2010). Restrained eaters show enhanced approach tendencies towards food. *Appetite, 55*, 30–36.
Veling, H., & Aarts, H. (2009). Putting behavior on hold decreases reward value of need-instrumental objects outside of awareness. *Journal of Experimental Social Psychology, 45*, 1020–1023.
Veling, H., & Aarts, H. Changing impulsive determinants of unhealthy behaviours towards rewarding objects. *Health Psychology Review*, in press-a.
Veling, H., & Aarts, H. Unintentional preparation of motor impulses after incidental perception of need-rewarding objects. *Cognition and Emotion*, in press-b.
Veling, H., Aarts, H., & Stroebe. (2011). Fear signals inhibit impulsive behavior toward rewarding food objects. *Appetite, 56*, 643–648.
Veling, H., Holland, R. W., & van Knippenberg, A. (2008). When approach motivation and behavioral inhibition collide: behavior regulation through stimulus devaluation. *Journal of Experimental Social Psychology, 44*, 1013–1019.

Verbruggen, F., & Logan, G. D. (2008). Automatic and controlled response inhibition: associative learning in the go/no-go and stop-signal paradigms. *Journal of Experimental Psychology: General, 137*, 649–672.

Voedingcentrum. (2011). Eettips voor je werkdag. Retrieved 05.05.11, from. http://www.voedingscentrum.nl/nl/mijn-gewicht/gezond-gewicht/balansdag/balansdag-op-het-werk1/eettips-voor-je-werkdag.aspx.

Ward, A., & Mann, T. (2000). Don't mind if I do: disinhibited eating under cognitive load. *Journal of Personality and Social Psychology, 78*, 753–763.

Wardle, J. (1986). The assessment of restrained eating. *Behaviour Research and Therapy, 24*, 213–215.

Wilson, G. T. (2010). Eating disorders, obesity and addiction. *European Eating Disorders Review, 18*, 341–351.