



Research report

Targeting impulsive processes of eating behavior via the internet. Effects on body weight[☆]



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ABSTRACT

Because eating behavior can take on an impulsive nature many people experience difficulty with dieting to lose weight. Therefore, an experiment was conducted to test the effectiveness of two interventions targeting impulsive processes of eating behavior to facilitate weight loss: Implementation intentions to remind people about dieting versus a go/no-go task to change impulses toward palatable foods. Dieters performed an online training program (four times in 4 weeks) in which they were randomly assigned to a 2 (implementation intention condition: dieting versus control) \times 2 (go/no-go task condition: food versus control) design. They formed either dieting implementation intentions (e.g., If I open the fridge I will think of dieting!) or control implementation intentions. Furthermore, they received either a go/no-go task in which behavioral stop signals were presented upon presentation of palatable foods (food go/no-go task), or upon control stimuli. Participants' weight was measured in the laboratory before and after the intervention. Strength of participants' dieting goal and their Body Mass Index (BMI; as a proxy for impulsiveness toward food) were examined as moderators. Results showed that both dieting implementation intentions and the food go/no-go task facilitated weight loss. Moreover, dieting implementation intentions facilitated weight loss particularly among people with a strong current dieting goal, whereas the food go/no-go task facilitated weight loss independent of this factor. Instead, the food go/no-go task, but not formation of dieting implementation intentions, was primarily effective among dieters with a relatively high BMI. These results provide the first preliminary evidence that interventions aimed at targeting impulsive eating-related processes via the internet can facilitate weight loss.

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Many people experience difficulty with restraining their consumption of palatable food that is very visible and easily available in the environment (e.g., Swinburn et al., 2011; WHO, 2000). This difficulty is reflected by the fact that many people gain weight despite having strong intentions to maintain or reduce their body weight (e.g., Klesges, Isbell, & Klesges, 1992). For some people this is such a problem that they are chronically trying to diet and lose weight (Herman & Polivy, 1980; Stroebe, 2008). However, there is a large literature showing that dieting intentions are often not effective for regulating one's consumption behavior (Elfhag & Rössner, 2005; Jeffery et al., 2000; Mann et al., 2007).

Consensus is growing that an important contributing factor to problems with eating regulation is the fact that mere perception of palatable foods in the environment can trigger consumption independent of people's dieting goals, and thus eating behavior can occur in a rather impulsive² fashion (Hall, 2012; Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). Therefore, we tested whether reducing the influence of impulsive processes on eating behavior may be effective in facilitating people's weight loss attempts (Marteau, Hollands, & Fletcher, 2012; Shalev & Bargh, 2011; Sheeran, Gollwitzer, & Bargh, 2013). Specifically, the aim of the present research is testing whether two recently developed interventions to reduce impulsive eating behavior can influence an important health outcome, i.e., weight loss among dieters. By testing both intervention approaches within one experimental design, the current research extends earlier

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² We use the term impulsive eating for eating that is facilitated by a motivational approach orientation (e.g., because of people's appetite or because of the rewarding or hedonic properties of foods or eating situations) or associative links (such as habits; Strack & Deutsch, 2004).

studies that mainly tested the effectiveness of the two intervention approaches in isolation. Furthermore, previous work investigated outcomes other than weight loss – the ultimate goal of most interventions.

Two general approaches to reducing the influence of impulsive processes of eating behavior can be distinguished. First, one approach aims to shift the balance from impulsive behavior to more goal-directed control of behavior by directing people's attention to their (often) long-term health goals (e.g., [Adriaanse, De Ridder, & De Wit, 2009](#); [Fujita & Han, 2009](#); [Houben, Nederkoorn, Wiers, & Jansen, 2011](#); [Papies & Hamstra, 2010](#)). Previous work suggests that this shift may be accomplished by the formation of implementation intentions that remind people of their dieting goal ([Kroese, Adriaanse, Evers, & De Ridder, 2011](#); [Van Koningsbruggen, Stroebe, Papies, & Aarts, 2011](#)). Implementation intentions are behavioral plans following an if–then structure creating a strong link between a specified situation and a response, making people select this response when entering the specified situation (e.g., [Gollwitzer, 1999](#); [Webb & Sheeran, 2007](#)). Studies using this planning procedure to prompt a dieting goal (e.g., “If I am tempted to consume palatable foods, I will think of dieting!”) have been found to activate the dieting goal in response to food temptations, and to decrease consumption of palatable foods among (chronic) dieters for a period of up to 2 weeks ([Kroese et al., 2011](#); [Van Koningsbruggen et al., 2011](#)). These strong effects of dieting reminders on consumption behavior may hence provide a means to overrule the impulsive nature of eating and to facilitate attempts at weight loss (cf., [Luszczynska, Sobczyk, & Abraham, 2007](#)).

Importantly, the effectiveness of improving dieting behavior through activation of the dieting goal via implementation intentions depends on people's current motivation to diet, because this intervention focuses on increasing opportunities for volition to influence behavior, and not on changing people's motivation ([Sheeran, Webb, & Gollwitzer, 2005b](#)). Accordingly, in the present research we expected that forming implementation intentions to think of dieting across different eating occasions would reduce eating behavior and hence facilitate weight loss among dieters, and that this effect would become stronger as a function of people's current strength of their dieting goal.

A second way to change impulsive eating behavior is by targeting behavioral impulses evoked upon the mere exposure to palatable food ([Hofmann, Friese, & Strack, 2009](#); [Seibt, Häfner, & Deutsch, 2007](#); [Veenstra & de Jong, 2010](#); [Veling, Holland, & van Knippenberg, 2008](#)). Recent work suggests that impulses triggered by palatable food and drinks can be reduced by linking images of such stimuli to behavioral stop signals in a go/no-go task (e.g., [Houben et al., 2011](#); [Veling & Aarts, 2009](#); [Veling, Aarts, & Papies, 2011](#)). Specifically, participants are presented with images of objects on screen and are requested to perform or withhold a response depending on a concurrently presented go or stop signal (e.g., a tone or a letter). In the experimental condition palatable foods are always presented with stop signals (hereafter referred to as food go/no-go task or fNoGo), whereas participants do not withhold their behavior toward such stimuli in the control condition (hereafter referred to as cNoGo). Work from different laboratories has found that the fNoGo is effective in reducing choice for or consumption of palatable food and alcoholic beverages ([Houben, 2011](#); [Houben & Jansen, 2011](#); [Houben et al., 2011](#); [Jones & Field, 2013](#); [Veling et al., 2011](#); [Veling, Aarts, & Stroebe, 2013](#)). In the case of food this effect is especially strong for people who are supposed to be more prone to the impulsive nature of eating behavior (e.g., [Houben, 2011](#); [Veling et al., 2011](#)), such as people who are overweight (e.g., [Batterink, Yokum, & Stice, 2010](#); [Nederkoorn, Coelho, Houben, Guerrieri, & Jansen, 2012](#); [Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010](#)).

While dieting implementation intentions and fNoGo have mostly been studied in isolation, recent research compared the effective-

ness of both interventions in reducing self-selected portion size of palatable food (i.e., sweets; [Van Koningsbruggen, Veling, Stroebe, & Aarts, in press](#)). In the fNoGo, participants learned to withhold a behavioral response on being presented with four different pictures of each of these sweets. In the dieting implementation intention condition, participants formed the implementation intention to think of dieting the next time they were tempted to eat sweets. In an apparently unrelated experiment, participants were then given the opportunity to select as many of the sweets as they wanted in a sweet shop-like environment. Results of two studies demonstrated that, although combining the interventions did not lead to additive effects, both interventions significantly reduced the amount of sweets participants selected for themselves.

The aims of the present study are much more ambitious than those of the study by [Van Koningsbruggen et al. \(in press\)](#). Instead of targeting portion size selection of a limited set of sweets, the present study aims at reducing people's weight over a 4-week period. Thus, having demonstrated that these two interventions were effective in reducing self-selected portion size under laboratory conditions and with a very limited set of food items, the present study was designed to test whether offering these two interventions via the internet would help dieters to lose weight.

Overview of the study

We presented the go/no-go task and implementation intention interventions online to examine whether presenting these interventions in an easy accessible format that could potentially reach many people is an effective way to facilitate weight loss ([Kazdin & Blase, 2011](#)). The training program was repeated for 4 consecutive weeks, and involved one training session per week that lasted for about 30 minutes. Before and after the intervention participants' weight was measured in the laboratory.

We predicted that participants receiving one (fNoGo only or dieting implementation intentions only) or both (fNoGo and dieting implementation intentions) experimental conditions would lose more weight than participants receiving both control conditions. Moreover, we explored whether the implementation intention intervention, but not the go/no-go task intervention, is moderated by dieting goal strength (e.g., [Sheeran et al., 2005b](#)). Instead, the go/no-go task intervention may be particularly effective among participants with a relatively high BMI (e.g., [Veling et al., 2011](#)).

Method

The study was conducted, and written informed consent of each participant was obtained in compliance with the principles contained in the Declaration of Helsinki.

Randomization, design, and participants

Experimenters were blind to condition during measurement in the laboratory, and participants were randomly assigned to one of four conditions of the 2 (implementation intention: control versus dieting) \times 2 (go/no-go task: cNoGo versus fNoGo) between-subjects design. Randomization was accomplished by providing participants at the end of the first session with randomly generated personal codes to log into the online intervention program (these codes ensured that participants would enter a specific condition of the design). Participants were recruited through advertisements across the university campus across three consecutive weeks.

Because the current study involves a first test of the effects of stop signals and dieting implementation intentions on weight loss, we examined a relatively homogeneous sample of participants who indicated they completed at least a school of higher general secondary education, and without severe obesity (defined as BMI >35).

Table 1
Characteristics of participants per condition.

	II control cNoGo N = 26	II control fNoGo N = 29	II dieting cNoGo N = 33	II dieting fNoGo N = 25	F-value (p)
Age	22.7 (5.1)	22.0 (2.7)	23.7 (6.6)	23.3 (6.9)	.54 (p = .65)
Sex (% of women)	92	90	94	80	1.1 (p = .36)
Weight (in kilograms)	70.4 (11.3)	70.7 (11.2)	71.4 (13.4)	71.7 (11.7)	.06 (p = .98)
Body Mass Index	24.9 (3.8)	24.2 (2.9)	24.0 (3.5)	24.5 (2.3)	.43 (p = .73)
Dieting goal	5.6 (1.6)	5.4 (1.4)	5.9 (1.0)	5.7 (1.1)	.86 (p = .46)

Note: Differences were tested in four group ANOVAs, $F(3,109)$. Standard deviations are presented between parentheses. II = implementation intentions, cNoGo = control go/no-go task, fNoGo = food go/no-go task.

Of the 131 participants that completed one or more training sessions, 16 dropped out of the study for various reasons (e.g., computer malfunction, too busy, illness; $N = 7$), or without giving a reason ($N = 9$). The number of drop-outs was evenly distributed across conditions (range 3–5). Furthermore, these participants did not differ from the participants who completed the study with regard to age, weight, BMI, percentage of women, dieting goal, perceived success, restraint, chronic dieting, and exercise, all $ps > .05$ (see below and the supplementary materials for further specification of these variables).

One participant who only performed one training session and had an extreme score on the main dependent variable (i.e., a value on weight loss more than three times the interquartile range from the lower quartile) was excluded. One participant could not be weighed properly after completing the training sessions because one of her legs was in plaster, and was excluded. Accordingly, the examined sample consisted of 113 participants, who performed three ($N = 18$) or four ($N = 95$) online training sessions. Participants indicated they were students ($N = 98$), or employed ($N = 14$), or unemployed ($N = 1$). Participants' ages ranged from 17 to 51 years. Other participant characteristics can be found in Table 1.

Materials

To select appropriate food pictures for the fNoGo, we first conducted a qualitative pilot study ($N = 30$), in which we asked people to indicate what they ate at different eating occasions (breakfast, dinner, snacking). Based on this pilot study we selected 100 pictures (of approximately 600×600 pixels) of food and drinks that are relatively high in caloric content and/or palatability (e.g., French fries, chips, salted nuts, pizza, pasta with cream sauce, lasagna, chocolate, ice cream, fried snacks, pancakes, muffin, cake, pie, cheese, cocktails, wine, beer, soda, juice). It is important to note that we selected pictures across a wide range of foods and drinks to increase chances that any effects of the intervention would generalize to similar foods and drinks (see also Houben et al., 2011). We also selected 100 filler pictures that were unrelated to food (e.g., bracelet, screws, and knots). These filler pictures were matched to the food pictures with regard to visual complexity and color.

Go/no-go task intervention

The go/no-go task intervention started with a short instruction screen stating that images would be presented on screen within either a blue or gray border. Participants read that their task was to press the space bar as quickly and accurately as possible when the border was blue, and to withhold responding when the border was gray. After reading this instruction participants started with the task. Each picture was presented for 1500 ms or until the participant responded. A blue or gray border appeared around the picture 100 ms after picture onset, and was visible during the time the picture remained on screen. The intertrial interval was 500 ms.

After an erroneous (non)response a red cross appeared for 500 ms.

In the fNoGo condition each food or drink picture (100 pictures in total) was accompanied by a gray border and the filler pictures (100 pictures in total) by a blue border. In the cNoGo condition the filler pictures were presented twice with each border color. Pictures were presented in random order. We did not present food pictures in the cNoGo, because of research suggesting that mere exposure to food stimuli may inhibit dieters' dieting goals (e.g., Fedoroff, Polivy, & Herman, 1997; Hofmann, Van Koningsbruggen, Stroebe, Ramanathan, & Aarts, 2010; Jansen & van den Hout, 1991; Rogers & Hill, 1989; Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008). Hence, inclusion of food stimuli in the cNoGo (e.g., by presenting them with go signals) may interfere with people's dieting attempts, which would lead to interpretational difficulties with regard to evaluating the effect of the fNoGo.

Implementation intention intervention

Next, participants received instructions for the implementation intentions, and it was stated to participants in all conditions that dieting attempts could be facilitated by planning. In the dieting implementation intention condition participants read that dieting attempts can be facilitated by planning to think of dieting. They were asked to make idiosyncratic implementation intentions with regard to five eating occasions (i.e., breakfast, lunch, snacks during the day, dinner, snacks after dinner). For each eating occasion, participants were first asked to think about the typical way in which such a situation unfolded (e.g., where, when and with whom they had breakfast). Next, they were asked to make a specific plan with regard to the best moment in time to be reminded of dieting, and type this plan into a text box (i.e., . . . I will think of dieting). For instance, with regard to breakfast several participants formed the implementation intention "If I open the fridge, I will think of dieting." This plan was then displayed for 30 seconds, and participants were asked to mentally simulate executing the implementation intention as vividly as possible.

In the control implementation intention condition participants were asked to make implementation intentions on taking it easy for five occasions (this time days of the week Monday–Friday). First, they were asked for each day how this day would typically unfold (e.g., where, when and with whom they woke up). Then, they were asked to form and visualize implementation intentions in a similar way as described above. For instance, for one participant the implementation intention for Monday was "If I hear my alarm clock, I will think of taking it easy." We did not ask participants to make these implementation intentions with regard to the eating occasions, because the implementation intention to take it easy (e.g., during breakfast; or any implementation intention for that matter) may then indirectly serve as a dieting reminder.

Procedure

Session 1

The first session was conducted over a period of 2 weeks in which all participants were tested one by one. After some general information about the study (e.g., duration, general purpose), and signing informed consent, participants started with answering a number of questionnaires on a computer. First, participants received six questions (7-point Likert scales ranging from 1 = totally disagree to 7 = totally agree) with regard to the strength of their current dieting goal (e.g., I will do my best to lose weight the coming month, I want to decrease my caloric intake the coming month; Cronbach's $\alpha = .95$). This factor (dieting goal strength) was included as a moderator in the analyses. For the sake of completeness we report other questionnaires that participants filled-out in the supplementary materials.

Next, participants received information about the training program. It was stated that the purpose of the study was to evaluate the effectiveness of different psychological methods to facilitate dieting behavior. Participants received a personal code, which they needed to access the training program. They were asked to write the numbers down on a note (or enter in their mobile phones), and store it away carefully so that they could access these numbers later. Next, we asked for participants' e-mail addresses and mobile phone numbers to be able to reach them during the course of the study. Participants were instructed that they would receive an e-mail with a link to a website, and that they could log in from home to do the training. Furthermore, it was made clear that we would use their mobile phone numbers and e-mail addresses to remind them of doing the training. It was stated that the training program would last for 4 consecutive weeks, and that they would return to the laboratory for additional questions after the training program.

Finally, participants' height and weight was measured. These measurements were used to calculate people's BMI (kg/m^2), which served as a moderator in the analyses. Moreover, weight was measured before the intervention as a baseline to evaluate effectiveness of the weight loss attempt.

Training program

The training program was repeated each week for 4 weeks. Each Tuesday following session 1 participants received an e-mail providing them with a link to access the training program. Participants were asked to do the training program at least 2 hours after consuming a meal, because previous work suggests that the fNoGo does not work when people are satiated (Veling et al., 2013). The online training program could be accessed via the participants' internet browsers, and was programmed in Inquisit 2.0. After entering their personal codes, participants first received a cued-recall questionnaire pertaining to their consumption behavior over the last 24 hours. Specifically, they were asked how many portions of food and drinks they consumed from 49 categories (e.g., sandwiches, plates of pasta, meat, fish, fried snacks, carbonated beverages, candy bars, glasses of water). See supplementary materials for analyses concerning this self-reported consumption measure. Next, they received the go/no-go task intervention followed by the implementation intention intervention. Specifically, and depending on condition, they received the cNoGo followed by either the control implementation intention intervention or dieting implementation intention intervention, or the fNoGo followed by either the control implementation intention intervention or the dieting implementation intention intervention.

Finally, each training each participant indicated his/her dieting goal strength (single item, 7-point scale; I will do my best to lose weight) dieting importance (single item, 7-point scale; It is important for me to lose weight), appetite (single item, 7-point scale; ranging from not at all to very much), time since last food intake

(in minutes), and e-mail address (to be able to verify that the code was entered correctly). These questions were asked to detect the development of any differences in motivation during the course of the training program, to examine possible differences between conditions in appetite as a function of exposure to food pictures in the go/no-go task, and to examine compliance with our instruction to do the training program at least 2 hours after consuming a meal. The training session lasted for approximately 25 minutes.

Session 2

At the end of the intervention that lasted for 4 weeks, participants were invited back into the laboratory. We asked them a number of questions with regard to the training (see supplementary materials). Then, participants were weighed again. Weight change since session 1 served as our main dependent variable. Finally, participants were thanked and paid for their participation.

Overview of statistical analyses

Analyses were performed using SPSS 20. We tested our hypothesis that participants would lose weight in all conditions except when they received both control conditions first conservatively in the General Linear Model (GLM) including the effect of time (weight session 1 versus weight session 2) as within-subjects factor and implementation intentions (control versus dieting) and go/no-go task (cNoGo versus fNoGo) as between-subjects factors. Next, we performed a more specific contrast test comparing weight loss (weight session 1 – weight session 2) of the group receiving both control conditions to the other conditions. Moreover, we tested the effect of time (weight session 1 versus weight session 2) within each condition in the GLM to evaluate whether each intervention would facilitate weight loss. After that we examined potential moderators of the effects in additional analyses using the GLM and Pearson correlations.

Results

Characteristics of the sample

Table 1 presents characteristics of the sample. Because we did not expect differences between conditions on any of these variables, we tested for possible differences in four group ANOVAs. There were no differences between conditions on any of these variables.

Go/no-go task performance and online measurements

Quantitative data acquired during the online training sessions are presented in the [Supplementary Table S2](#) in the online version at [doi:10.1016/j.appet.2014.03.014](https://doi.org/10.1016/j.appet.2014.03.014). Participants made few errors in the go/no-go task (1.56%), and the maximum error percentage for each individual training session did not exceed 10%. No differences in error rates on go trials or no-go trials between conditions in each training session were found. These results indicate that participants performed the go/no-go task in a similar and satisfactory way independent of whether the task contained food stimuli.

There were also no reliable differences between conditions on dieting goal strength, dieting importance, appetite, or food deprivation at the time of the conduct of the training. The results further indicate that participants generally complied well with our instructions to do the online training at least 2 hours after consuming a meal, and continued to do so over the course of the training. For descriptive information see [Supplementary Table S2](#) in the online version at [doi:10.1016/j.appet.2014.03.014](https://doi.org/10.1016/j.appet.2014.03.014).

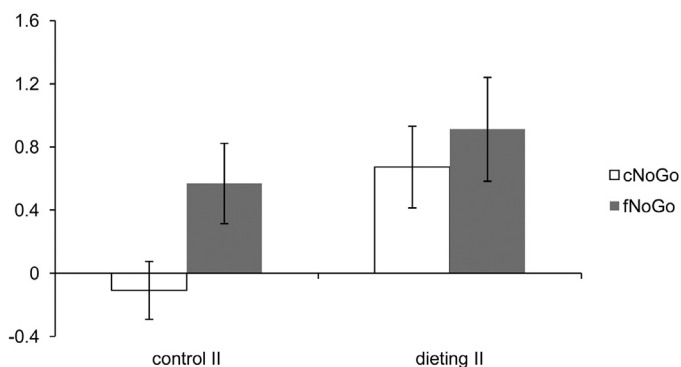


Fig. 1. Weight loss (weight session 1 – weight session 2) in kilograms as a function of implementation intention condition and go/no-go task condition. II = implementation intentions, cNoGo = control go/no-go task, fNoGo = food go/no-go task; Error bars = SE.

Main analyses

First, we analyzed weight loss in the General Linear Model including the effect of time (weight session 1 versus weight session 2) as within-subjects factor and implementation intentions (control versus dieting) and go/no-go task (cNoGo versus fNoGo) as between-subjects factors. This analysis revealed a significant effect of time, $F(1,109) = 15.18$, $p < .01$, $\eta_p^2 = .12$, which was qualified by a significant time by implementation intentions interaction, $F(1,109) = 4.58$, $p = .04$, $\eta_p^2 = .04$, and a marginally significant time by go/no-go task interaction, $F(1,109) = 3.04$, $p = .08$, $\eta_p^2 = .03$. The higher order interaction between these three factors was not significant, $F < 1$, $p = .41$. As can be seen in Fig. 1 the pattern of results is in the predicted direction.

Next, we tested the difference in weight loss (weight session 1 versus weight session 2) between the condition that lacked both dieting implementation intentions and the fNoGo and the other conditions in a contrast test (condition with both control conditions versus the other conditions). This test was significant $F(1,109) = 7.07$, $p < .01$, $\eta_p^2 = .06$. Additional analyses revealed that the effect of time (weight session 1 versus weight session 2) was not significant in the cNoGo/control implementation intention condition ($F < 1$, $p = .56$), but significant within all other conditions (fNoGo/control implementation intention condition, $F(1,28) = 5.01$, $p = .03$, $\eta_p^2 = .15$; cNoGo/dieting implementation intention condition, $F(1,32) = 6.77$, $p = .01$, $\eta_p^2 = .18$; fNoGo/dieting implementation intention condition, $F(1,24) = 7.69$, $p = .01$, $\eta_p^2 = .24$). Thus, as predicted, participants lost weight in all conditions except when participants did not perform the fNoGo and formed no dieting implementation intentions (see Fig. 1).

Additional analyses

Next, we tested the possible moderating influence of dieting goal strength (in case of implementation intention but not go/no-go task) and BMI (in the case of go/no-go task but not implementation intention) on weight loss. Because we test specific predictions, with regard to these variables based on the literature, we tested the moderating influence of these variables in theory driven analyses rather than in a full model including all possible main, two-way, three-way and four-way effects (which substantially lower degrees of freedom).³ For ease of interpretation we performed the analyses

³ Testing the full model on weight loss revealed that the predicted effects were all significant (main effect go/no-go task, interaction between implementation intention and dieting goal) or marginally significant ($ps < .094$; implementation intention, BMI, dieting goal, interaction between go/no-go task and BMI), whereas there were no unpredicted effects, $Fs < 1$, $ps > .32$.

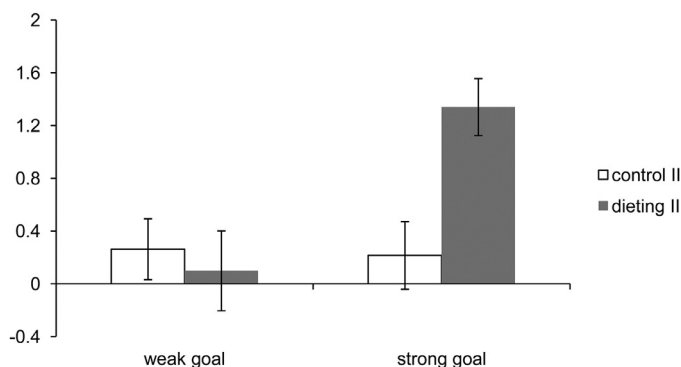


Fig. 2. Weight loss (weight session 1 – weight session 2) in kilograms as a function of dieting goal strength (1 SD below and above the standardized dieting goal score) and implementation intention condition. II = implementation intentions; Error bars = SE.

below on weight loss (weight session 1 – weight session 2), so that the factor time could be omitted in these analyses.

Moderating role of goal strength

First, we tested whether the effect of implementation intention is moderated by strength of the dieting goal. Therefore, we tested the effects of implementation intention, go/no-go task, dieting goal (standardized score) and their interactions on weight loss in the General Linear Model. This analysis revealed a marginally significant effect of implementation intention, $F(1,105) = 3.44$, $p = .07$, and significant effects of go/no-go task, $F(1,105) = 4.60$, $p = .03$, $\eta_p^2 = .04$, dieting goal strength, $F(1,105) = 4.73$, $p = .03$, $\eta_p^2 = .04$, and the predicted interaction between dieting goal strength and implementation intention, $F(1,105) = 5.50$, $p = .02$, $\eta_p^2 = .05$. Importantly, no interaction between dieting goal strength and go/no-go task was found, $F < 1$, $p = .76$, nor any other significant effects, $Fs < 1$, $ps > .34$. Because dieting goal strength was correlated with BMI ($r(113) = .32$, $p < .01$), we repeated this analysis controlling for (standardized) BMI. In this analysis the crucial interaction between dieting goal strength and implementation intention remained significant, $F(1,104) = 5.97$, $p = .02$, $\eta_p^2 = .05$, and the interaction between dieting goal strength and go/no-go task remained nonsignificant, $F < 1$, $p = .61$. So, dieting goal strength is related to the effectiveness of the implementation intention intervention, and unrelated to the effect of the go/no-go task.

To explore the interaction between dieting goal strength and implementation intention we examined the effect of implementation intention among participants with a relatively weak goal strength (1 standard deviation below the standardized score of dieting goal strength) and participants with relative strong dieting goal strength (1 standard deviation above the standardized score of dieting goal strength; see Aiken & West, 1991 for this regression analysis; see Fig. 2). Among participants with weak dieting goals, dieting implementation intentions are not more effective to lose weight ($M = .10$, $SE = .30$) compared with control implementation intentions ($M = .26$, $SE = .23$), $F < 1$, $p = .67$ (see left side of Fig. 2). In contrast, participants with strong dieting goals lost more weight after formation of dieting implementation intentions ($M = 1.34$, $SE = .27$) compared with control implementation intentions ($M = .22$, $SE = .26$), $F(1,105) = 9.02$, $p < .01$, $\eta_p^2 = .08$ (see right side of Fig. 2).

Furthermore, dieting goal strength was correlated with weight loss within the dieting implementation condition, $r(55) = .32$, $p = .02$, but not in the control implementation condition, $r(58) = -.05$, $p = .70$ (these respective correlations when controlling for BMI are, $r(55) = .28$, $p = .04$ and $r(52) = -.12$, $p = .40$). So, dieting implementation intentions appear to facilitate weight loss more strongly as dieting goal strength is higher.

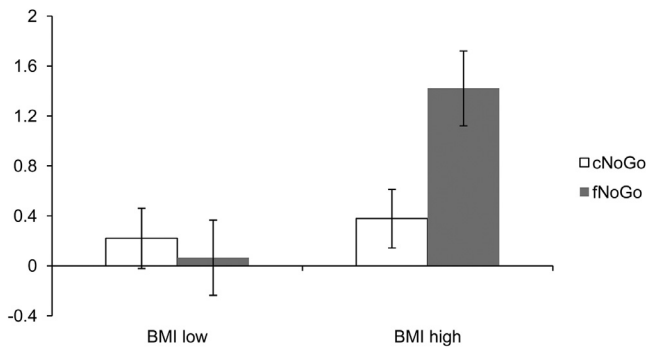


Fig. 3. Weight loss (weight session 1 – weight session 2) in kilograms as a function of BMI (1 SD below and above the standardized BMI score) and go/no-go task condition. BMI = Body Mass Index; cNoGo = control go/no-go task, fNoGo = food go/no-go task; Error bars = SE.

Moderating role of BMI

Then, we tested whether the effect of the go/no-go task is moderated by BMI with an analysis on weight loss including the factors go/no-go task, implementation intention, BMI (standardized score) and their interactions in the General Linear Model. This analysis revealed a marginally significant effect of go/no-go task, $F(1,105) = 2.97$, $p = .09$, $\eta_p^2 = .03$, and significant effects of implementation intention, $F(1,105) = 4.36$, $p = .04$, $\eta_p^2 = .04$, BMI, $F(1,105) = 7.13$, $p < .01$, $\eta_p^2 = .06$, and the interaction between go/no-go task and BMI, $F(1,105) = 4.46$, $p = .04$, $\eta_p^2 = .04$. Importantly, no interaction between BMI and implementation intention was found, $F < 1$, $p = .40$, nor any other significant effects. We repeated this analysis controlling for dieting goal strength. In this additional analysis the test for the interaction between go/no-go task and BMI remained significant, $F(1,104) = 4.61$, $p = .03$, $\eta_p^2 = .04$, and the interaction between implementation intention and BMI remained nonsignificant, $F < 1$, $p = .35$. Thus, the effectiveness of the go/no-go task is moderated by BMI, and the effectiveness of the implementation intention intervention is not moderated by BMI.

To explore the interaction between go/no-go task and BMI we first examined the effect of go/no-go task among participants with a relatively low BMI (1 standard deviation below the standardized score of BMI) and participants with relative high BMI (1 standard deviation above the standardized score of BMI; see Fig. 3). Among participants with low BMI the fNoGo was not more effective to lose weight ($M = .07$, $SE = .30$) compared with the cNoGo ($M = .22$, $SE = .24$), $F < 1$, $p = .69$ (see left side of Fig. 3). In contrast, participants with high BMI lost more weight in the fNoGo condition ($M = 1.42$, $SE = .30$) compared with the cNoGo condition ($M = .38$, $SE = .23$), $F(1,105) = 7.52$, $p < .01$, $\eta_p^2 = .07$ (see right side of Fig. 3).

Furthermore, BMI was correlated with weight loss within the fNoGo condition, $r(54) = .36$, $p < .01$, but not in the cNoGo condition $r(59) = .15$, $p = .25$ (the respective correlations when controlling for dieting goal strength are, $r(51) = .33$, $p = .02$, and, $r(56) = -.01$, $p = .93$). So, the fNoGo appears to facilitate weight loss more strongly as people's BMIs are higher.

Discussion

The present experiment provides first insight into the effectiveness of two interventions targeting impulsive processes of eating in affecting people's weight via the internet. First, the present study revealed that formation of implementation intentions that remind people of dieting can facilitate weight loss. Implementation intentions are a well-studied tool to facilitate health behavior (Gollwitzer, 1999; Sheeran, Milne, Webb, & Gollwitzer, 2005a), but most studies to date have focused on activating concrete behaviors in specific situ-

ations to facilitate health behavior (e.g., Armitage, 2004; Luszczynska et al., 2007; Verplanken & Faes, 1999; for a review in the domain of eating behavior, see Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011). The present research adds to this large field of research by showing that implementation intentions to remind people about their dieting goal (Kroese et al., 2011; Van Koningsbruggen et al., 2011, in press) can facilitate weight loss.

The fact that using implementation intentions to activate the concept of dieting facilitated weight loss converges well with previous work that has shown that presenting dieting reminders in food environments such as restaurants, or activate them via implementation intentions, can reduce dieters' consumption of palatable food (Anschutz, Van Strien, & Engels, 2008; Kroese et al., 2011; Papies & Hamstra, 2010; Van Koningsbruggen et al., 2011) and increase healthy food choice (Papies & Veling, 2013). The present research suggests that implementation intentions reminding dieters about their dieting goal may be used as a basis for developing interventions to facilitate weight loss attempts.

Second, the current study provides the first evidence that a go/no-go task in which foods are consistently presented in close temporal proximity of stop signals can be effective in facilitating weight loss. Indeed, results show that in the absence of dieting implementation intentions participants' lose weight after four short sessions of fNoGo, but not after cNoGo. This result is consistent with previous work showing that the fNoGo is effective in reducing consumption of high calorie foods (e.g., Houben & Jansen, 2011; Veling et al., 2011), and extends these findings by revealing that performing the fNoGo across 4 weeks can facilitate weight loss.

In addition to these new insights, the present study provides important suggestive evidence for the underlying mechanisms that contribute to the effectiveness of dieting implementation intentions and the fNoGo in facilitating weight loss. First, the implementation intention intervention was sensitive to individual differences in the strength of people's dieting goals. This result is consistent with the goal-conflict theory of eating behavior (Stroebe et al., 2008) predicting that dieting reminders are effective in facilitating dieting behavior among people that have the goal to diet (Papies & Veling, 2013; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). Moreover, this finding is consistent with a broader literature showing that volitional interventions such as implementation intentions are effective among motivated individuals (Sheeran et al., 2005a). Hence, this moderation pattern speaks to the validity of our findings.

Second, and also consistent with previous work, the fNoGo was found to be sensitive to individual differences in people's BMIs, but not to individual differences in the strength of people's dieting goals (Veling et al., 2011). The fact that the implementation intention intervention was not moderated by BMI suggests that this moderation pattern is not simply caused by the fact that there is more room to lose weight when BMI is higher. Considering that BMI is related to sensitivity of the reward value (and hence impulse-evoking quality) of high calorie food (e.g., Batterink et al., 2010; Bruce et al., 2010; Demos, Heatherton, & Kelley, 2012; Stice, Spoor, Bohon, Veldhuizen, & Small, 2008), these results are consistent with the hypothesis that the fNoGo facilitated dieting behavior by modifying impulses toward food. Moreover, the present experiment suggests that by targeting this proximal determinant of eating behavior, strength of people's dieting goals becomes less important in facilitating weight loss. Note that the absence of a relation between the go/no-go manipulation and the strength of goal measure cannot be attributed to insensitivity of the goal measure as this measure did moderate the results of the implementation intention intervention. However, because BMI is only an indirect indicator of impulses, and impulses were not measured in the current study, more work is needed to arrive at strong conclusions on this topic.

In the present experiment we did not observe an interaction between implementation intentions and go/no-go task, which is

interesting in light of a previous study employing the same design that did observe an interaction effect when it comes to self-serving of sweets (Van Koningsbruggen et al., in press). So how can we explain the differences in the pattern of findings? There are two major differences between these two studies which both, independently or jointly, could have been responsible for the differences in patterns.

First, in the study of Van Koningsbruggen et al. (in press) a very limited selection of one food type (sweets) was used. Participants could take as much as they wanted from each of two or three different sweets. This allowed the researchers to induce participants to withhold responses to all the tempting stimuli they would encounter later in their selection of portion sizes. In contrast, in the present experiment one cannot be certain about the extent to which the pictures used in the fNoGo corresponded to the food that would be encountered by our participants in the various eating situations.

This is also true for the formation of implementation intentions, but to a lesser extent. Whereas in the study of Van Koningsbruggen et al. (in press) the implementation intention to think of dieting could be formed with regard to the type of food later encountered, implementation intentions in the present experiment were much more general, namely to think of dieting at the beginning of the various eating occasions. Thus, whereas there was a complete overlap between the two interventions in the sweet selection study, the overlap was much less complete in the present study. As a result, the implementation intention to think of dieting might have reduced consumption of foods that were not included in the go/no-go task and the stop-signal learning might have reduced the consumption of food at times when the effect of the implementation intention had weakened and participants were no longer thinking of dieting (e.g., toward the end of a meal).

A second major difference between the two studies is in the type of outcome variable. Whereas the study of Van Koningsbruggen et al. (in press) measured selection of portion size, the present study assessed weight loss and thus, indirectly, the amounts of food the participants eat. Although there is a great deal of evidence that the size of the portions people are given influences the amount they eat (e.g., Van Kleef, Shimizu, & Wansink, 2012; Wansink & Cheney, 2005), this correspondence is not perfect. Furthermore, these experiments usually do not allow participants to select a second portion of food, whereas this is easily possible during a normal dinner occasion when food has been particularly tasty. It is possible that the go/no-go task and implementation intentions influence the selection of portion size through the same pathway, but have different effects on the decision to limit the amount of food that is being eaten.

Because the present research was conducted as a first test to evaluate whether interventions targeting impulsive eating processes can affect weight loss across a couple of weeks, more work is needed before the current interventions can be recommended as weight loss tools. The present research has three important limitations with regard to this issue. First, we only examined people's weight across a period for 4 weeks. Hence, it remains to be tested whether the interventions can lead to weight loss over longer periods of time. An important area for future study is to test how long effects of one or multiple sessions of the interventions last, so that recommendations can be made concerning the frequency of implementing the interventions to reach optimal effects.

Second, although our research suggests that the fNoGo works especially for people with a relatively high BMI, and independent of people's strength of their dieting goal, it should be noted that we currently examined a population of reasonably motivated dieters with an average BMI of around 24. Therefore, it remains to be tested whether the fNoGo can be effective to reduce weight in populations that are not at all motivated to diet, or that have higher levels of BMI. Finally, we did not find differences in people's food con-

sumptions, so the exact process by which the interventions reduce weight needs to be tested. Possibilities include effects on buying behavior, food choice, portion selection, or amount of consumption.

In the current work, we have found evidence that psychological interventions that target impulsive processes of eating behavior can facilitate weight loss attempts with or without strong dieting goals. The fact that the interventions were effective even when presented with little social support in a very accessible manner (i.e., via the internet) suggests that further research in this direction may be a worthwhile endeavor (Kazdin & Blase, 2011).

Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.appet.2014.03.014.

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