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Research report

# Chocolate equals stop. Chocolate-specific inhibition training reduces chocolate intake and go associations with chocolate

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Earlier research has demonstrated that food-specific inhibition training wherein food cues are repeatedly and consistently mapped onto stop signals decreases food intake and bodyweight. The mechanisms underlying these training effects, however, remain unclear. It has been suggested that consistently pairing stimuli with stop signals induces automatic stop associations with those stimuli, thereby facilitating automatic, bottom-up inhibition. This study examined this hypothesis with respect to food-inhibition training. Participants performed a training that consistently paired chocolate with no go cues (chocolate/no-go) or with go cues (chocolate/go). Following training, we measured automatic associations between chocolate and stop versus go, as well as food intake and desire to eat. As expected, food that was consistently mapped onto stopping was indeed more associated with stopping versus going afterwards. In replication of previous results, participants in the no-go condition also showed less desire to eat and reduced food intake relative to the go condition. Together these findings support the idea that food-specific inhibition training prompts the development of automatic inhibition associations, which subsequently facilitate inhibitory control over unwanted food-related urges.



## Introduction

Globally, obesity has nearly doubled since 1980 and continues to rise unabated (Finucane et al., 2011). It is the fifth leading risk factor for deaths worldwide by placing individuals at the risk of cardiovascular diseases, diabetes, musculoskeletal disorders and cancer (World Health Organization, 2009). In the interest of individual and public health, this obesity pandemic calls for effective interventions to reduce excessive bodyweight and obesity, and thereby obesity-related morbidity and mortality. Ultimately, obesity can be explained as the result of a simple equation: Excessive calorie consumption, without extra energy expenditure, converts calories into fat deposits and results in weight gain. The implications are relatively straightforward: In order to achieve weight loss, one needs to reduce daily caloric intake, increase psychical activity, or do both. For many, however, this equation is easily understood but difficult to balance.

Self-control may be the critical factor in this knowledge-behavior gap. Self-control refers to "the ability to override or change one's inner responses, as well as to interrupt undesired behavioral tendencies (such as impulses) and refrain from acting on them" (Tangney, Baumeister, & Boone, 2004, p. 274). Similarly, contemporary dual-process theories state that failures of self-control occur due to the inability to inhibit impulses that are activated by salient temptations (e.g., Hofmann, Friese, & Strack, 2009). Specifically, dual-process models like the Reflective-Impulsive Model (Hofmann et al., 2009; Strack & Deutsch, 2004) describe two qualitatively different processes and how they guide behavior: The reflective system represents a slow-acting and controlled system that serves to direct behavior toward long-term goals and personal standards. The impulsive system operates in a relatively automatic manner wherein responses to stimuli are derived from affective and motivational associations with these stimuli. Whenever a conflict between these two systems arises, enacting the goal-directed behavior (e.g., stick to a diet) requires the inhibition of automatic impulses (e.g., indulge in chocolate cake). Importantly, the successful resolution of such self-control conflicts critically depends on inhibitory control capacity. Hence, the inability to adhere to the simple principles of the energy balance equation could be due to inhibitory control failure: When unable to actively inhibit behavioral impulses that are incompatible with one's goals, such as wanting to indulge in a delicious piece of chocolate cake when trying to diet, impulses will dictate behavior at the expense of becoming overweight. Individual differences in inhibitory control may thus very well explain why some people do not succeed in resisting the temptation of palatable, high calorie foods and achieving or maintaining a healthy weight.

In line with this idea, less effective inhibitory control is associated with increased food intake and overeating (Guerrieri,

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Nederkoorn, & Jansen, 2007; Guerrieri et al., 2007), increased bodyweight and obesity (Guerrieri, Nederkoorn, & Jansen, 2008; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Verbeken, Braet, Claus, Nederkoorn, & Oosterlaan, 2009), and less weight loss during treatment (Nederkoorn, Jansen, Mulkens, & Jansen, 2007). Moreover, recent research suggests that overweight and obesity are not so much related to inhibitory control in general, but rather to food-specific inhibitory control deficits (Houben, Nederkoorn, & Jansen, 2014; Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012). Thus, the available evidence supports a crucial role for inhibitory control, in particular when confronted with tasty foods, in the prevention and treatment of excessive bodyweight and obesity.

These findings subsequently prompted many studies that examined the possibility of training inhibitory control to reduce food intake and overweight (Houben, 2011; Houben & Jansen, 2011; Koningsbruggen, Veling, Stroebe, & Aarts, 2013; Veling, Aarts, & Papies, 2011; Veling, Aarts, & Stroebe, 2013; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014). Overall, these studies show that training the inhibition of responses to food reduces choices for those foods that were consistently paired with stopping or inhibiting a response (Koningsbruggen et al., 2013; Veling et al., 2013), decreases consumption of those foods (Houben, 2011; Houben & Jansen, 2011; Veling et al., 2011) and facilitates weight loss (Veling et al., 2014). Similar results were demonstrated also in other domains like excessive alcohol consumption (Bowley et al., 2013; Houben, Havermans, Nederkoorn, & Jansen, 2012; Houben, Nederkoorn, Wiers, & Jansen, 2011; Jones & Field, 2013).

Though promising as a means of promoting behavioral change, the mechanisms underlying the effects of this kind of inhibition training still remain unclear. Current literature on training inhibitory control suggests that improvements may follow either from the strengthening of top-down, controlled inhibition or from the development of automatic forms of inhibition (Verbruggen & Logan, 2008). Recent evidence suggests it is unlikely that this kind of inhibition training operates by strengthening general, top-down inhibitory control abilities. First, general inhibition training has shown rather disappointing results in both the food domain (Guerrieri, Nederkoorn, & Jansen, 2012) and the alcohol domain (Jones & Field, 2013), suggesting that stimulus-specific training may be more effective in changing health behavior. Second, stimulus-specific training failed to produce significant improvements on general response inhibition, while results did show behavioral change (i.e., less undesired specific behavior) following training (Houben et al., 2012). Hence, the available evidence does not support the idea that food-specific inhibition training strengthens top-down inhibitory control. However, it has not yet been examined whether this kind of inhibition training may facilitate bottom-up, automatic inhibitory control.

Importantly, it has been suggested that, in conditions where certain stimuli are consistently and repeatedly paired with stop cues, people may gradually learn to associate these stimuli with stopping (Verbruggen & Logan, 2008). Once such associations are established, the stimuli may directly elicit inhibition, thereby bypassing slow, top-down inhibitory control, and facilitating the stopping process. Whether such automatic inhibitory processes are indeed induced by food-specific inhibition training has not yet been investigated. The aim of the current study therefore was to examine whether consistently pairing food-related stimuli with stop cues indeed induces automatic associations between those stimuli and stopping. To examine this hypothesis, participants performed a Go/No-Go training task during which pictures of chocolate were consistently paired with stop cues or always paired with go cues. Following the Go/No-Go task, we assessed automatic associations between chocolate and stopping versus going, desire to eat and chocolate consumption during a bogus taste test. It was hypothesized that the consistent pairing of chocolate with inhibition cues would induce automatic associations between chocolate and stopping. Further, in replication of our previous research (Houben & Jansen, 2011), we expected that participants who consistently inhibited their responses to chocolate would report less desire to eat and would show reduced food intake relative to participants who were allowed to respond to chocolate.

## Method

### *Participants*

Fifty-two female undergraduate students were recruited from the student population at Maastricht University using advertisements posted in the university buildings and the Psychology department's online study participation system.[1] The advertisements asked for female volunteers, who liked to eat chocolate on a regular basis, to participate in experimental research. Participants were excluded if they had severe to moderate underweight (BMI < 18.5), disliked the chocolate that was presented during the taste test (mean rating < 5), or were outliers (more than 2.5 standard deviations from their group mean) on one of the dependent measures (SCIAT score, desire to eat, or food intake during the taste test). These exclusions resulted in a final sample of 41 participants (chocolate/no-go: $n = 21$; chocolate/go: $n = 20$). Participants were aged 18–25 years ($M = 20.13$, $SD = 1.73$). The two conditions were well matched in terms of age, BMI, dietary restraint, trait chocolate craving, and taste ratings (see Table 1). The study protocol was approved by the local ethical committee of the Faculty of Psychology and Neuroscience.

### *Materials and measures*

#### *Go/no-go task*

The Go/No-Go task consisted of 2 blocks of 160 trials. During each block, participants were presented with pictures and were instructed to press the space bar when a go cue was displayed on the picture, and to refrain from responding when a no-go cue was displayed on the picture. The go and no-go cues were the letters 'p' and 'f', which were displayed randomly in one of four corners of the pictures. Go/no-go instructions were counterbalanced so that the letter 'p' was the go cue (and 'f' the no-go cue) for half the participants, and for the other half of participants, 'p' was the no-go cue (and 'f' the go cue). Stimuli consisted of four pictures of chocolate snacks (a mixture of different types of chocolate including milk chocolate, plain chocolate, and chocolate with nuts or caramel), four neutral pictures of empty plates, and 8 filler pictures (snack foods; e.g., crisps, nuts). Filler stimuli were used to mask the goal of the study and to avoid demand characteristics.[2] Each trial simultaneously presented a picture and a go/no-go cue (1000 ms). Participants had to respond by pressing the space bar when the picture was accompanied by the go cue, but had to refrain from responding when the picture was accompanied by the no-go cue. A green circle was displayed after a correct (non)response (500 ms), and a red cross an after incorrect (non)response (500 ms). The inter-trial interval was 500 ms.

Participants were randomly assigned to one of two conditions. In the chocolate/no-go condition ($n = 26$), chocolate-related pictures were consistently paired with the no-go cue, while pictures of empty plates were consistently paired with the go cue. The eight filler pictures were presented with the go cue on half the trials and

[1] This sample size yielded 80% power to detect medium to large group differences ($f \geq .40$).

[2] Before debriefing, participants were asked about their ideas regarding the goal of the study. None of the participants correctly guessed the purpose of the study.