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Do impulsive individuals benefit more from food go/no-go training? Testing the role of inhibition capacity in the no-go devaluation effect

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ABSTRACT

Not responding to food items in a go/no-go task can lead to devaluation of these food items, which may help people regulate their eating behavior. The Behavior Stimulus Interaction (BSI) theory explains this devaluation effect by assuming that inhibiting impulses triggered by appetitive foods elicits negative affect, which in turn devalues the food items. BSI theory further predicts that the devaluation effect will be stronger when food items are more appetitive and when individuals have low inhibition capacity. To test these hypotheses, we manipulated the appetitiveness of food items and measured individual inhibition capacity with the stop-signal task. Food items were consistently paired with either go or no-go cues, so that participants responded to go items and not to no-go items. Evaluations of these items were measured before and after go/no-go training. Across two preregistered experiments, we consistently found no-go foods were liked less after the training compared to both go foods and foods not used in the training. Unexpectedly, this devaluation effect occurred for both appetitive and less appetitive food items. Exploratory signal detection analyses suggest this latter finding might be explained by increased learning of stimulus-response contingencies for the less appetitive items when they are presented among appetitive items. Furthermore, the strength of devaluation did not consistently correlate with individual inhibition capacity, and Bayesian analyses combining data from both experiments provided moderate support for the null hypothesis. The current project demonstrated the devaluation effect induced by the go/no-go training, but failed to obtain further evidence for BSI theory. Since the devaluation effect was reliably obtained across experiments, the results do reinforce the notion that the go/no-go training is a promising tool to help people regulate their eating behavior.

1. Introduction

Today's world is filled with appetitive foods: in kiosks at train stations, in supermarkets and grocery stores, on television, appetitive foods are everywhere. Appetitive foods automatically attract our attention (Nijs, Muris, Euser, & Franken, 2010), activate the brain's reward regions (Wang et al., 2004), and excite the motor system (Gupta & Aron, 2011), so that we may easily notice, desire, and eventually obtain and consume them. Because of our innate preference for calories (Breslin, 2013), appetitive foods are often energy-dense and contain much sugar and fat. Excessive intake of appetitive yet energy-dense foods is broadly considered a major contributor to increased body weight and the worldwide obesity epidemic we are facing right now (World Health Organization, 2016).

Although many people are living in an obesogenic environment, gaining weight is not inevitable. Appetitive energy-dense foods may trigger potent impulses and urges, but people also have the capacity to inhibit these impulses and regulate their thoughts and behaviors. This capacity to inhibit predominant responses is termed *inhibition*, which is one of three main executive functions (*inhibition*, *updating* and *shifting*, respectively; Miyake & Friedman, 2012). Individuals differ in their capacity to inhibit impulses, and this difference in inhibition capacity may have implications for regulating eating behaviors. For instance, individuals with relatively low inhibition capacity consume more appetitive foods in the lab (Guerrieri et al., 2007), and their consumption of foods is more

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strongly determined by their automatic affective reactions to foods than individuals with high inhibition capacity (Hofmann, Friese, & Roefs, 2009). People with low inhibition capacity and strong implicit preferences for snack foods also gain most weight over a year (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Furthermore, obese and overweight individuals show lower inhibition capacity in comparison to healthy controls (Kulendran et al., 2014; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006a; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006b; for a meta-analysis, see Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016), suggesting that low inhibition capacity may be a contributing factor to overweight.

If the problem in regulating eating behaviors stems from the difficulty in inhibiting impulses evoked by appetitive foods, reducing the strength of the impulses triggered by foods should help people to better regulate their eating behaviors. Inspired by this idea, several training procedures have been developed, and one such training is the go/no-go training (GNG training), in which participants consistently respond to some stimuli (e.g., by pressing a key, go trials) and withhold their responses to other stimuli (e.g., do not press any key, no-go trials). When used as training on foods, appetitive energy-dense foods can be consistently presented on no-go trials so that participants do not respond to these foods. Previous research showed that after GNG training, appetitive foods are evaluated less positively (Chen, Veling, Dijksterhuis, & Holland, 2016; Veling, Aarts, & Stroebe, 2013a) and are chosen less often (Veling, Aarts, & Stroebe, 2013b; Veling et al., 2013a). When offered a chance to consume these appetitive foods in the laboratory, participants consume fewer of them if these foods have been paired with no-go trials in the training (Folkvord, Veling, & Hoeken, 2016; Houben & Jansen, 2011, 2015; Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015b). Moreover, repeated training with high-calorie foods has been shown to facilitate weight loss attempts in two studies (Lawrence et al., 2015a; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014; for a recent meta-analysis, see Allom, Mullan, & Hagger, 2015).

Not responding to appetitive foods thus leads to decreased evaluation. One explanation for such devaluation effect is offered by Behaviour Stimulus Interaction theory (BSI theory, Veling, Holland, & van Knippenberg, 2008). According to BSI theory, exposure to appetitive foods triggers an impulse to approach the foods. However, when these foods are presented together with a no-go cue, participants need to engage in response inhibition in order to overcome this impulse. This conflict between the impulse to respond and response inhibition elicits negative affect. After repeated pairings, the negativity of the conflict is attached to the appetitive foods, leading to decreased evaluation of them.

BSI theory posits that the strength of the conflict is jointly determined by two competing processes: the initial impulses triggered by the food items, and the response inhibition process to overcome and inhibit these impulses. The first prediction from BSI theory is that the devaluation effect induced by response inhibition in GNG training should be stronger for stimuli that are more appetitive, since appetitive stimuli trigger stronger impulses, and the strength of the resulting conflict is accordingly higher. In line with this idea, previous research has shown that GNG training is more effective in lowering the evaluations of positive stimuli than that of neutral or negative stimuli (Veling et al., 2008; Chen et al., 2016; but see Frischen, Ferrey, Burt, Pistchik, & Fenske, 2012). The influence of GNG training on food choices is also stronger when people have a relatively high appetite, presumably because individuals with a high appetite experience strong impulses toward appetitive foods (Veling et al., 2013a). Furthermore, several studies showed that GNG training is especially effective for restrained eaters (Houben & Jansen, 2011; Houben, 2011; Lawrence et al., 2015b; Veling, Aarts, & Papies, 2011). Restrained eaters chronically restrict food intake to lose weight, but are mostly unsuccessful and often end up consuming more than non-restrained eaters (Fedoroff, Polivy, & Herman, 1997; Stirling & Yeomans, 2004). One reason for their failure to control body weight is that restrained eaters respond more strongly to appetitive foods (Brunstrom, Yates, & Witcomb, 2004; Harvey, Kemps, & Tiggemann, 2005; Papies, Stroebe, & Aarts, 2007; Veenstra & de Jong, 2010), and this might again explain why GNG training is more effective for them.

The second prediction that can be derived from BSI theory is that the effectiveness of GNG training depends on the response inhibition process. In line with this idea, recent research found that increasing the proportion of no-go trials in GNG training, thereby presumably reducing the engagement and activation of response inhibition on no-go trials, renders the GNG training procedure unsuccessful in triggering devaluation, suggesting a causal role of response inhibition in inducing devaluation (Chen et al., 2016; for discussions on to what degree GNG training evokes motor inhibition toward the stimuli, see also Wessel, O'Doherty, Berkebile, Linderman, & Aron, 2014; Veling, Lawrence, Chen, van Koningsbruggen, & Holland, 2017). Furthermore, Adams, Lawrence, Verbruggen, and Chambers (2017) recently showed that inhibition trainings (GNG training and stop-signal training) with higher rates of inhibition accuracy are more effective in modifying food intake, corroborating the idea that successful response inhibition leads to devaluation. Another way to address this question is by examining individual differences in inhibition capacity. More specifically, for individuals with low inhibition capacity, inhibiting an impulse might be more difficult and conflict-inducing than for individuals with high inhibition capacity. The devaluation effect may therefore be larger when individuals have lower inhibition capacity. Indirect evidence came from studies with restrained eaters (Houben & Jansen, 2011; Houben, 2011; Lawrence et al., 2015b; Veling et al., 2011). As mentioned above, GNG training is more effective for restrained eaters, and as restrained eaters in general have lower inhibition capacity (Nederkoorn, Van Eijs, & Jansen, 2004; measured by the stop-signal task, Logan, Cowan, & Davis, 1984), this pattern of results could thus be interpreted as in line with this second prediction. Note that since restrained eaters are both highly responsive to food cues and have low inhibition capacity, these previous findings cannot disentangle the two predictions made by BSI theory. More direct support for the claim that training may be more effective for individuals with low inhibition capacity comes from a study by Houben (2011), in which participants first received the stop-signal task to measure their inhibition capacity, and then performed response inhibition training (albeit a training based on the stop-signal task, not the GNG training) on high-calorie foods. Food intake was reduced after the training, but only for individuals with low inhibition capacity, suggesting that the effectiveness of the training is indeed related to individual difference in inhibition capacity.

Combined, these two predictions suggest an interesting and useful feature of the GNG training. That is, GNG training becomes more effective when food items are more appetitive and when people have low inhibition capacity to inhibit their impulses – the situation where excessive intake of calories is most likely to occur (Nederkoorn et al., 2010). Although all the findings reviewed above are in line with these two predictions, the evidence is still relatively scarce, especially for the role of inhibition capacity in moderating devaluation effect. Furthermore, to the best of our knowledge, these two predictions have never been jointly tested in one design. This interactive process between the impulsive approach tendencies and the response inhibition process, as outlined by BSI theory, is therefore still not entirely clear. Further examining this process will not only provide more theoretical insight into the