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Beating uncontrolled eating: Training inhibitory control to reduce food intake and food cue sensitivity

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ABSTRACT

In our food-rich environment we must constantly resist appealing food in order to maintain a healthy lifestyle. Previous studies have found that food-specific inhibition training can produce changes in eating behaviour, such as a reduction in snack consumption. However, the mechanisms that drive the effect of inhibition training on eating behaviour remain unknown. Identifying the mechanism underlying food-specific inhibition training could lead to more targeted training interventions increasing the potential efficacy of such interventions. In the current study, we investigated directly whether training-induced effects on inhibitory control might underlie the predicted change in eating behaviour. Healthy individuals who scored high on uncontrolled eating were randomly assigned to receive six online training sessions over six consecutive days of either food-specific response inhibition training (active group; $n = 21$) or response inhibition training without food stimuli (control group; $n = 20$). We measured pre- and post-training inhibitory control in the context of food and food cue sensitivity, as well as food consumption in a bogus taste test. As expected, food-specific inhibition training decreased snack consumption in the bogus taste test relative to control training. However, the active training did not improve inhibitory control towards food, nor did it reduce food cue sensitivity above and beyond the control training. Future studies are needed to investigate the potential underlying mechanism of food-specific inhibition training, as it remains unclear what drives the reliable effect on eating behaviour.

We are living in an obesogenic environment where we are constantly confronted with advertisement for foods, and overeating of unhealthy foods is an important contributor to the rising levels of obesity (Hill, Wyatt, Reed, & Peters, 2003). Although almost everyone overeats on occasion, some people overeat on a more regular basis, despite efforts to resist overeating or attempts to make healthier food choices. Uncontrolled eating refers to a tendency to overeat, accompanied by feelings of being out of control (Anglé et al., 2009), and is a characteristic of various eating disorders, such as bulimia nervosa and binge eating disorder (American Psychiatric Association, 2013) as well as obesity (Cornelis et al., 2014).

An important factor in regulating eating behaviour and resisting palatable food is inhibitory control (i.e. response inhibition): an executive function that is required to inhibit impulsive responses so that behaviour can be selected that is consistent with one's standards and (long-term) goals (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Individuals with weaker inhibitory control are more often overweight or obese (Guerrieri, Nederkoorn, & Jansen, 2008; Nederkoorn, Breat, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009; Nederkoorn, Jansen, Mulkens, & Jansen, 2007) and their dieting is more often unsuccessful compared to individuals with stronger inhibitory control (Jansen et al., 2009). Reduced inhibitory control has also been directly related with increased food intake in the lab (Guerrieri et al., 2007), especially in non-dieters (Guerrieri, Nederkoorn, Schrooten, Martijn, & Jansen, 2009). Although the link between behaviourally measured inhibitory control and food intake (in the lab) is not always replicated, there is more consistent evidence for self-reported increased impulsivity and food intake (Guerrieri et al., 2008; Guerrieri, Nederkoorn, & Jansen, 2007).

Another important factor in regulating eating behaviour and resisting palatable food is food reward sensitivity: the degree to which neurological reward responses to food cues elicit the motivation to eat (Berridge, Ho, Richard, & DiFeliceantonio, 2010). Food reward sensitivity has been found to predict food intake (Lawrence, Hinton, Parkinson, & Lawrence, 2012), weight gain (Demos, Heartherton, &

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Kelley, 2012), obesity (Stice, Spoor, Bohon, Veldhuizen, & Small, 2008) and bulimia nervosa (Brooks et al., 2011). However, findings by Lawrence et al. (2012) suggest that individual differences in inhibitory control may moderate the impact of food reward sensitivity on body mass index (BMI). Lawrence et al. (2012) found that food reward sensitivity was associated with increased BMI in individuals reporting low inhibitory control. Interestingly, food reward sensitivity was negatively correlated with BMI in individuals reporting high inhibitory control.

These findings of previous studies are in line with traditional dual process models. This theoretical model emphasizes the role of inhibitory control whenever there is conflict between two different systems – an impulsive system and reflective system – that operate in parallel and compete for action control (e.g. Kahneman & Frederick, 2002; Strack & Deutsch, 2004). The impulsive system evaluates stimuli in terms of affective and motivational significance, and based on that evaluation predisposes one to either approach or avoid. Unlike the impulsive system, the reflective system is flexible, slow and controlled, and enables personal standards and (long-term) goals to influence decisions and actions via top-down cognitive control (Strack & Deutsch, 2004). Without inhibitory control the reflective system would not be able to overrule the initial response of the more fast-acting impulsive system.

Although a dual-process model might serve as a useful way to describe impulsive and reflective processes, more recent articles argue for a unitary model of action control (Hommel & Wiers, 2017). This unitary model considers all behaviours to be goal-directed. Goals can act as selection criteria that under certain conditions may promote actions that are simple, fast, and overlearned (stimulus-driven actions), or actions that are slow, complex and more controlled (value-driven actions). As an example, although most individuals would report reluctance to indulge in unhealthy foods in a motivationally ‘neutral’ situation, this intention can weaken when being primed with palatable foods or when hungry. Individual preferences for fast-acting decision making versus slow and controlled decision-making could then translate into individual differences regarding ‘acceptable’ behaviour, such as overeating. Reduced inhibitory control may not imply an inability to translate intentions into action but may relate to a preference for fast-acting (impulsive) decisions based on salient cues (Hommel & Wiers, 2017). Overeating could thus depend on an interaction between individual differences in food reward sensitivity (sensitivity to salient cues) and inhibitory control. For a full discussion of the unitary model, see Hommel and Wiers (2017).

Considering the findings of previous studies that indicate a relationship between inhibitory control and overeating behaviour it should come as no surprise that there has been a growing interest in targeting inhibitory control to help people refrain from overeating. A task that is repeatedly used to measure inhibitory control is the go/no-go task, in which people are instructed to respond as fast as possible to ‘go’ items, and to withhold their response to ‘no-go’ items (Donders, 1969). Researchers have developed food-specific go/no-go training tasks in which unhealthy food items are consistently paired with a no-go cue aiming to improve response inhibition for food stimuli (Houben & Jansen, 2011). Such food-specific go/no-go training has been found to reduce food intake (Veling, Aarts, & Stroebe, 2013b, 2013a; Adams, Lawrence, Verbruggen, & Chambers, 2017; Houben, 2011; Houben & Jansen, 2011, 2015; Lawrence, Verbruggen, Morisson, Adams, & Chambers, 2015b; Van Koningsbruggen, Veling, Stroebe, & Aarts, 2014; Veling, Aarts, & Papies, 2011), facilitate weight-loss (Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015b; Veling, Van Koningsbruggen, Aarts, & Stroebe, 2014), and reduce self-served food portion sizes (Van Koningsbruggen et al., 2014). Recent meta-analyses found that inhibitory control training using the go/no-go paradigm has a moderate effect on reducing appetitive behaviours in healthy samples (Allom, Mullan, & Hagger, 2016; Jones et al., 2016; Turton, Bruidegom, Cardi, Hirsch, & Treasure, 2016).

Although these studies and meta-analyses show promising effects, the underlying mechanisms of change for the food-specific go/no-go training remain unclear. Houben and Jansen (2011) postulated that the training strengthens top-down inhibitory control over food-related responses. Besides strengthening top-down inhibitory control, two alternative explanations have been since postulated for how food response inhibition training may reduce food consumption (Veling, Lawrence, Chen, Van Koningsbruggen, & Holland, 2017): 1. training could create automatic ‘bottom-up’ associations between no-go food items and stopping responses (automatic inhibition); 2. training leads to devaluation of food items. This second alternative mechanism is based on Behaviour Stimulus Interaction (BSI) theory. The BSI theory proposes that devaluation of appetitive food stimuli takes place when an initial approach response to appetitive food stimuli is inhibited in order to prevent continuous oscillation between approach and inhibition (Chen, Veling, Dijksterhuis, & Holland, 2016).

Given the aim of the training, the most obvious mechanism of change would be that the training strengthens top-down inhibitory control over food-related responses. Veling et al. (2017) have argued that this is unlikely as the training task is very easy and a type of training that is considered more demanding for top-down control, the stop-signal training, is generally less effective (Allom et al., 2016; Jones et al., 2016). However, we cannot rule out this proposed mechanism, because none of the aforementioned training studies measured transfer from the training task to an inhibitory control task to determine if inhibitory control (for food) improved. Nor did they test whether a change in inhibitory control was underlying the change in eating behaviour. This proposed mechanism is thus yet to be experimentally demonstrated. The alternative mechanism that training increases ‘automatic inhibition’ is often hard to disentangle from the suggestion that training increases top-down inhibitory control. It is possible to look at a slowing of reaction times for responding to trained no-go items when these are presented on go trials but this may only occur when attention to these no-go items is increased during training (Veling et al., 2017).

Veling et al. (2017) have argued that so far the most supported mechanism underlying food go/no-go training is a devaluation of food items. Although some studies indeed found that training led to food devaluation when measured with explicit rating scales of food items (Chen et al., 2016), other studies using the Implicit Association Task found no evidence for devaluation of appetitive stimuli (Jones et al., 2016). One study did find that devaluation of no-go food stimuli was related to weight loss after training, but devaluation did not mediate the effect of go/no-go training (Lawrence et al., 2015a). The evidence that food go/no-go training leads to a devaluation of food and underlies the effects of training on food intake thus remain mixed. Therefore, we were interested to test if food specific go/no-go training would reduce food cue induced craving. Unlike explicitly asking individuals to rate food items on a visual analogue scale (Chen et al., 2016), this measures individual's craving response to food items and could thus be seen as a physical equivalent of food evaluation or the evaluated incentive value of food.

Investigating the underlying working mechanism of the food-specific go/no-go training is theoretically valuable as it will allow us to increase our understanding of the cognitive processes that contribute to food intake and overeating. This could further support models of uncontrolled eating (and binge eating) that propose a central role for inhibitory control or suggest the need for fine-tuning such models by incorporating other processes (e.g. food cue sensitivity or food evaluation). Moreover, improving our understanding of the working mechanisms of food-specific go/no-go training will ultimately have clinical benefits as it allows for development of more sophisticated cognitive training protocols (e.g. as add-on to other treatment of binge eating or obesity) targeting specific processes to increase effectiveness on reducing unhealthy food intake.