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Training response inhibition to reduce food consumption: Mechanisms, stimulus specificity and appropriate training protocols

Rachel C. Adams [a,*], Natalia S. Lawrence [a,b], Frederick Verbruggen [b], Christopher D. Chambers [a]

[a] School of Psychology and Cardiff University Brain Research Imaging Centre, Cardiff University, Park Place, Cardiff CF10 3AT, UK
[b] School of Psychology, College of Life and Environmental Sciences, University of Exeter, Exeter EX4 4QG, UK

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ABSTRACT

Training individuals to inhibit their responses towards unhealthy foods has been shown to reduce food intake relative to a control group. Here we aimed to further explore these effects by investigating the role of stimulus devaluation, training protocol, and choice of control group. Restrained eaters received either inhibition or control training using a modified version of either the stop-signal or go/no-go task. Following training we measured implicit attitudes towards food (Study 1) and food consumption (Studies 1 and 2). In Study 1 we used a modified stop-signal training task with increased demands on top-down control (using a tracking procedure and feedback to maintain competition between the stop and go processes). With this task, we found no evidence for an effect of training on implicit attitudes or food consumption, with Bayesian inferential analyses revealing substantial evidence for the null hypothesis. In Study 2 we removed the feedback in the stop-signal training to increase the rate of successful inhibition and revealed a significant effect of both stop-signal and go/no-go training on food intake (compared to double-response and go training, respectively) with a greater difference in consumption in the go/no-go task, compared with the stop-signal task. However, results from an additional passive control group suggest that training effects could be partly caused by increased consumption in the go control group whereas evidence for reduced consumption in the inhibition groups was inconclusive. Our findings therefore support evidence that inhibition training tasks with higher rates of inhibition accuracy are more effective, but prompt caution for interpreting the efficacy of laboratory-based inhibition training as an intervention for behaviour change.

1. Introduction

Obesity rates have risen sharply over the last few decades, creating a global epidemic with gross implications for personal and economic health (e.g. Bray, 2004; Fry & Finley, 2005; Mokdad et al., 2003). One of the common explanations for the obesity epidemic is the environment and the availability of highly varied, palatable and fattening foods (Cummins & Macintyre, 2006; French, Story, & Jeffery, 2001; Jeffery & Utter, 2003; Levitsky, 2005; McCrory et al., 1999). However, despite the 'obesogenic environment' in which we live, there is considerable variation in weight status across individuals. For some, the ability to resist such tempting foods remains a constant challenge, whereas others find it relatively easy to exercise self-control over their calorie intake and maintain a healthy lifestyle. This leads us to the question of why some individuals are able to succeed where others fail?

Dual process models argue that our behaviour is determined by the interaction of an impulsive system, which is driven by our hedonic needs, and a reflective system, which involves conscious thought and deliberation (Strack & Deutsch, 2004). In the case of overeating it is possible that vulnerable individuals possess strong impulsive desires for calorie-dense foods and a lack of control over these desires (e.g. Houben, Nederkoorn, & Jansen, 2012b; Lawrence, Hinton, Parkinson, & Lawrence, 2012; Price, Lee, & Higgs, 2016; Volkow et al., 2003, 2002,; White, Whisenhunt, Williamson, Greenway, & Netemeyer, 2002; for a review see; Stice, Lawrence,

* Corresponding author. School of Psychology, College of Biomedical and Life Sciences, Cardiff University, 70 Park Place, Cardiff, CF10 3AT, UK.
E-mail addresses: adamsrc1@cardiff.ac.uk (R.C. Adams), Natalia.Lawrence@exeter.ac.uk (N.S. Lawrence), F.L.J.Verbruggen@exeter.ac.uk (F. Verbruggen), Chambersc1@cardiff.ac.uk (C.D. Chambers).

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Kemps, & Veling, 2016). This has encouraged researchers to develop new behavioural interventions designed to target these processes. For example, recent studies have shown that training individuals to inhibit simple motor responses to images of food, using either the stop-signal or go/no-go tasks, can result in the decreased consumption of that food (Houben & Jansen, 2011, 2015; Houben, 2011; Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015a; Veling, Aarts, & Papies, 2011), healthier food choices (van Koningsbruggen, Veling, Stroebe, & Aarts, 2014; Veling, Aarts, & Stroebe, 2013a; Veling, Aarts, & Stroebe, 2013b) and even weight loss (Lawrence et al., 2015b; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014). Three recent meta-analyses have demonstrated small to medium effect sizes for the effect of food-related inhibition training compared to control training (Allom, Mullan, & Hagger, 2015; Jones et al., 2016; Turton, Bruidegom, Cardi, Hirsch, & Treasure, 2016). However, there are some inconsistencies in training effects and several questions remain unanswered. In the two studies presented here, we sought to investigate the mechanisms involved in these training effects and whether such effects are reliant upon stimulus-specific associations between the stop-signal and the trained food. For example, inhibition training may be most effective when strong automatic associations are formed between the foods and a successful stop response (Jones et al., 2016). Stimulus-specific training effects would therefore result in reduced consumption of the trained foods only, whereas generalised effects could see reduced consumption of other unhealthy foods or even healthy foods. Following from the results of Study 1, we also compared the effectiveness of two different training protocols, stop-signal and go/no-go, and investigated the consumption of both unhealthy and healthy foods following training. Furthermore, we examined whether these training effects were the result of reduced food consumption in the training groups or whether they could be attributed to increased consumption in the 'food-go' control groups.

2. Study 1

In Study 1 we investigated whether stop-signal training could reduce food consumption relative to a control task, and whether any effects of training were due to the devaluation of inhibited stimuli (i.e. a reduction in the perceived incentive value or attractiveness of the stimulus). It has been argued that the inhibition of responses towards a desired object can result in stimulus devaluation (Doallo et al., 2012; Frischen, Ferrey, Burt, Pistchik, & Fenske, 2012; Verbruggen, McLaren, & Chambers, 2014a; Wessel, O'Doherty, Berkebile, Linderman, & Aron, 2014), a process that may occur in order to resolve action conflict (Veling, Holland, & van Knippenberg, 2008) or due to the inherent links between avoidance and aversion (McLaren & Verbruggen, 2016; Verbruggen, Best, Bowditch, Stevens, & McLaren, 2014b). Lawrence et al. (2015b) and Veling et al. (2013b) have both provided evidence for inhibition-induced stimulus devaluation when they found that foods paired with inhibition during a food-related go/no-go task were rated less positively than foods associated with responding. Changes in *implicit* attitudes have also been shown to mediate the effect of alcohol-related go/no-go training on weekly alcohol intake in heavy drinkers (Houben, Havermans, Nederkoorn, & Jansen, 2012a; Houben, Nederkoorn, Wiers, & Jansen, 2011). To date, evidence for the stimulus devaluation hypothesis is equivocal (e.g. Bowley et al., 2013; Houben et al., 2012a), with a recent meta-analysis showing no evidence for an effect of inhibition training on stimulus devaluation across six food and alcohol-related inhibition training studies (Jones et al., 2016). However, there are several gaps in this literature, with no published studies exploring the effect of alcohol-related inhibition training on explicit attitudes or food-related inhibition training on implicit attitudes. In addition, there are no studies investigating whether food or alcohol stimuli are devalued following stop-signal (as opposed to go/no-go) training.

The aim of Study 1 was to address one of these gaps by training participants on a food-related stop-signal task and measuring both implicit attitudes towards food and food consumption. In accordance with previous suggestions that inhibition training is most effective for those with a strong impulsive desire towards food (Veling et al., 2011), we restricted our sample *a priori* to participants who scored highly on measures of chocolate craving and dietary restraint. This sample has also previously been shown to respond positively to go/no-go training (Houben & Jansen, 2011). Participants were randomly allocated to either a stop training or control group. Those in the stop group performed a stop-signal task in which they had to inhibit their responses to chocolate stimuli on the majority of trials, whereas those in the control group made an additional response on chocolate trials (double-response group). As the presentation of the stop signal in the stop-signal task requires not only response inhibition but also additional error monitoring, rule maintenance, attentional control and response selection processes, this double-response task was believed to be an appropriate control condition (Lawrence et al., 2015a; Tabu, Mima, Aso, Takahashi, & Fukuyama, 2011; Verbruggen, Adams, & Chambers, 2012; Verbruggen, Aron, Stevens, & Chambers, 2010; Wessel et al., 2014).

Compared to the double-response group, it was hypothesised that participants in the stop group would show a reduced positive implicit attitude and/or an increased negative implicit attitude towards chocolate (measured using two unipolar, Single-Category Implicit Association Tests [SC-IAT]; Greenwald, McGhee, & Schwartz, 1998; Houben, Roefs, & Jansen, 2010; Karpinsky & Steinman, 2006 and also that they would consume fewer calories in a bogus taste test. Stimulus-specific effects on food intake were also investigated by including crisps in both the training task as 'go' foods (presented alongside stop-signals on a minority of trials) and the taste test. In accordance with previous research we expected that the stop group would show reduced consumption of the chocolate only (Houben, 2011; Lawrence et al., Study 2, 2015a; Veling et al., 2013a). Any effect of training on crisp intake could imply the occurrence of underlying mechanisms other than stimulus devaluation such as an increase in general self-control or response inhibition (Baumeister, Gailliot, DeWall, & Oaten, 2006; Berkman, Burklund, & Lieberman, 2009; Berkman, Graham, & Fisher, 2012; Jones et al., 2011; Muraven, 2010; Verbruggen et al., 2012).

2.1. Method

Fig. 1 provides a schematic diagram of the procedure for Study 1.

2.1.1. Participants

One hundred and forty-three restrained (15 + on the Restraint Scale; Herman & Polivy, 1980) chocolate cravers (10 + on the Attitudes to Chocolate Questionnaire Craving Scale; Benton, Greenfield, & Morgan, 1998, p. 134 females; aged 18–61, $M = 22.92$, $SE = 0.68$) were pseudo-randomly divided into the stop ($n = 71$, 66 females) and double-response groups ($n = 72$, 68 females) with an attempt to keep age and gender evenly distributed. Sample size was determined according to a Bayesian inferential stopping rule for the main effect of total calorie intake between groups; see Statistical Analysis in the Supplementary Information. Participants were recruited from the staff and student population at Cardiff University and were not eligible if they were currently dieting (with a weight goal and timeframe in mind) or if they had any history of eating disorders. All