Clinical Psychology Review 49 (2016) 16–27

Contents lists available at ScienceDirect

Clinical Psychology Review

journal homepage: www.elsevier.com/locate/clinpsychrev

Review

Training motor responses to food: A novel treatment for obesity targeting implicit processes

Eric Stice [a,*], Natalia S. Lawrence [b], Eva Kemps [c], Harm Veling [d]

[a] Oregon Research Institute, 1776 Millrace Drive, Eugene, OR 97403, USA
[b] School of Psychology, University of Exeter, Exeter EX4 4QG, UK
[c] School of Psychology, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia
[d] Behavioural Science Institute, Radboud University Nijmegen, PO Box 9104, 6500 HE Nijmegen, The Netherlands

HIGHLIGHTS

- Greater reward and attention region response to palatable food predicts weight gain.
- Response inhibition training with food reduces reward region hyper-responsivity.
- Response inhibition training with food has also produced weight loss.
- Response training works best for those with the strongest approach response to food.
- Response training may represent a new cost effective treatment for obesity.

ARTICLE INFO

Article history:
Received 5 October 2015
Received in revised form 18 January 2016
Accepted 7 June 2016
Available online 21 July 2016

Keywords:
Neural vulnerability factors
Prospective brain imaging
Weight gain
Obesity
Inhibition
Reward
Attention
Food
Weight-loss treatment
Response training
Attentional retraining

ABSTRACT

The present review first summarizes results from prospective brain imaging studies focused on identifying neural vulnerability factors that predict excessive weight gain. Next, findings from cognitive psychology experiments evaluating various interventions involving food response inhibition training or food response facilitation training are reviewed that appear to target these neural vulnerability factors and that have produced encouraging weight loss effects. Findings from both of these reviewed research fields suggest that interventions that reduce reward and attention region responses to high calorie food cues and increase inhibitory region responses to high calorie food cues could prove useful in the treatment of obesity. Based on this review, a new conceptual model is presented to describe how different cognitive training procedures may contribute to modifying eating behavior and important directions for future research are offered. It is concluded that there is a need for evaluating the effectiveness of more intensive food response training interventions and testing whether adding such training to extant weight loss interventions increases their efficacy.

Contents

* Corresponding author.
E-mail addresses: estice@ori.org (E. Stice), Natalia.lawrence@exeter.ac.uk (N.S. Lawrence), eva.kemps@flinders.edu.au (E. Kemps), h.veling@psych.ru.nl (H. Veling).

http://dx.doi.org/10.1016/j.cpr.2016.06.005
0272-7358/

The prevalence of obesity has risen dramatically worldwide and is credited with 2.8 million premature deaths annually (World Health Organization, 2013). Yet the most common treatment, behavioral weight-loss interventions, almost never results in lasting weight loss (Turk et al., 2009). Although bariatric surgery can produce more persistent weight loss, it is invasive, associated with medical complications, often contraindicated, and can cost over $30,000 (Martin, Beekley, Kjorstad, & Sebesta, 2010; Puzziferri et al., 2014). Thus, it is vital to identify novel efficacious treatments for obesity.

Prospective brain-imaging studies indicate that elevated reward region response to food cues and lower inhibitory control region response predict future excessive weight gain. These data imply that interventions that reduce reward region responsivity and increase inhibitory region responsivity to food cues might prove useful in the treatment of obesity. Fortunately, cognitive science experiments indicate that training people to inhibit a behavioral response to high-calorie food, which appears to target these neural vulnerability factors, produces weight loss, suggesting that food response-inhibition training may represent an efficacious strategy for treating obesity. Such translational neuroscience and cognitive science research holds great promise because it is based on objective behavioral and biological data from rigorous experiments, and aims to develop interventions that target bottom-up implicit, automatic processes in response to food cues, rather than relying on top-down effortful control and sustained caloric deprivation like most current treatments.

The aim of the present review is to summarize results from prospective brain imaging studies focused on identifying neural vulnerability factors that predict excessive weight gain and to review findings from cognitive psychology experiments that have evaluated various interventions that involve food response inhibition or food response facilitation training that appear to reduce these neural vulnerability factors and have produced weight loss effects. To discuss possible common mechanisms across these different interventions, the review focuses on intervention tasks in which manual responses to images of food are manipulated. Accordingly, interventions to change responses toward food that do not include manual responses as a central component, e.g., different kinds of conditioning procedures (e.g., Baeyens, Eelen, Van den Bergh, & Crombez, 1992; Hollands, Prestwich, & Marteau, 2011) are not discussed. The review focuses specifically on interventions that are assumed to target biased attentional processing, automatic approach responses, and poor inhibitory control toward food. Important parallels with alcohol consumption research are drawn when relevant for exploring the proposed mechanisms of the training tasks. Based on this review a new conceptual model is presented to describe how different cognitive training procedures may modify eating behavior. This model can be used to predict whether there is added value in combining different training tasks. Important directions for future research to extend this program of study are highlighted.

1. Neural vulnerability factors that predict future weight gain

Obese versus lean humans show greater response of brain regions implicated in reward/motivation (striatum, amygdala, orbitofrontal cortex [OFC]) and attention (anterior cingulate cortex [ACC]) to high-calorie food images (e.g., Frankort et al., 2012; Holsen et al., 2012; Martin et al., 2010; Stice, Yokum, Bohon, Marti, & Smolen, 2010; Stoeckel et al., 2008). They also show greater recruitment of motor response regions when exposed to high-calorie food images (Brooks, Cedernaes, & Schiöth, 2013; Jastreboff et al., 2013; Pursey et al., 2014), consistent with the known increased motor excitability and automatic approach responses elicited by palatable foods and their cues (Chiu, Cools, & Aron, 2014; Freeman, Alvernaz, Tonnesen, Linderman, & Aron, 2015; Freeman, Razhas, & Aron, 2014; Meule et al., 2014), which suggests an elevated motor approach tendency in obesity. These three findings have been confirmed in a large meta-analytic review of cross-sectional studies comparing neural response to palatable food images in obese versus lean individuals (Pursey et al., 2014), implying these relations are robust. Behavioral data likewise indicate that obese versus lean humans show greater attentional bias for high-calorie food images according to Stroop tests (Braet & Crombez, 2003; Nijs, Franklen, & Muris, 2010a) and eye-tracking (Castellanos et al., 2009; Graham, Hoover, Cellabos, & Komogortsev, 2011). Further, elevated reward region response to palatable food images and receipt of such foods also predicted greater ad lib food intake (Lawrence, Hinton, Parkinson, & Lawrence, 2012; Nolan-Poupart, Veldhuizen, Geha, & Small, 2013), as did attentional bias for high-calorie food (Nijs, Muris, Euser, & Franklen, 2010b; Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014).

Although it is reassuring that these cross-sectional studies have produced relatively consistent effects, they do not establish that elevated reward and attention region responsivity to high-calorie foods predates overeating and subsequent weight gain or is a result of overeating or obesity. High-risk and prospective designs are necessary to establish temporal precedence. One high-risk study found that healthy weight adolescents at high versus low risk for future weight gain based on parental obesity show greater striatal and OFC response to high-calorie food tastes and monetary reward (Stice, Yokum, Burger, Epstein, & Small, 2011). More critically, prospective fMRI studies have found that elevated OFC response to cues that signal impending presentation of high-calorie food images (Yokum, Ng, & Stice, 2011), elevated nucleus accumbens response to high-calorie food images (Demos, Heatherton, & Kelley, 2012), elevated substantia nigra, ventral tegmental area, hypothalamus, anterior thalamus, ventral pallidum, and nucleus accumbens response to high-calorie food receipt (Geha, Aschenbrenner, Felsted, O'Malley, & Small, 2013), and elevated striatal response to high-calorie food commercials (Yokum, Gearhardt, Harris, Brownell, & Stice, 2014) predicted future weight gain in samples containing lean, overweight, and obese individuals. Results appear consistent with evidence that elevated resting state activation in regions implicated in reward processing (e.g., ventral medial prefrontal cortex [vmPFC]) predicted future weight gain (Dong, Jackson, Wang, & Chen, 2015). However, because it is possible that a history of overeating may have contributed to this elevated responsivity of brain reward regions, it is important to test whether elevated reward region responsivity to food stimuli predicts initial excessive weight gain. One study found that elevated OFC response to cues signaling impending high-calorie food receipt among healthy weight adolescents predicted future excessive weight gain (Stice, Burger, & Yokum, 2015). Obese individuals who evidenced greater reward and attention region response to high-calorie food images also showed poorer response to behavioral weight loss treatment (Murdaugh, Cox, Cook, & Weller, 2012), consistent with the notion that hyper-responsivity of these regions may maintain overeating.