Changing 'gut feelings' about food: An evaluative conditioning effect on implicit food evaluations and food choice

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Abstract

The aim of this study was to test the effect of an evaluative conditioning (EC) task on implicit food evaluations and choices between healthy and unhealthy food, and whether the effect of the EC task on food choice would be mediated by implicit food evaluations. To induce the EC effect on implicit food evaluations and food choice, images of healthy and unhealthy foods were repeatedly paired with images of positively and negatively valenced faces, the pairing (healthy-positive/unhealthy-negative or healthy-negative/unhealthy-positive) manipulated between participants. Implicit food evaluations were measured using an Implicit Association Task (IAT), and food choice was measured using a food decision-making task consisting of 22 choices between healthy and unhealthy food items. Results showed a direct effect of EC condition on implicit food evaluations, but not on explicit food choice for the whole sample. However, an indirect effect of the EC task on food choice, mediated by implicit food evaluations, was found. Contingency awareness – whether participants were aware that foods were being paired with valenced stimuli – did not affect the strength of the EC effect, nor did attention to the EC task. Surprisingly, emotional eating was found to moderate the effect of the EC task on both implicit food evaluations and food choice, showing that the EC task had an effect only for those who scored low on emotional eating. In conclusion, this study makes a unique contribution to the EC literature by showing that food choice can be altered by conditioning implicit food evaluations, but that this may only work for people who do not score particularly high on emotional eating.

Highlights:

- A single EC session altered implicit food evaluations for the whole sample.
- A single EC session did not alter explicit food choice directly for the whole sample.
- Controlling for restrained eating, the EC task affected food choice indirectly, through implicit food evaluations.
- Contingency awareness and EC task attention both did not statistically moderate the EC effect, although the EC effect on implicit food evaluations was present in those who were contingency aware and not those who were contingency unaware.
- Emotional eating moderated the effect of the EC task; an EC effect was found on both implicit food evaluations and food choice in those scoring low, but not high, on emotional eating.

1. Introduction

The rapid rise of obesity is quickly becoming one of the biggest problems in the western world, at both personal and societal levels. Obesity has been identified as a risk factor for psychological, social and emotional issues (Falkner et al., 2001; Carr & Friedman, 2005; Jackson, Beeken, & Wardle, 2015). Moreover, obesity is a risk factor for many severe physical health issues, such as heart disease and diabetes (Mokdad et al., 2003; Must et al., 1999). Thus as an attempt to reduce incidence and negative ramifications of obesity, a large amount of psychological research in the previous decade has been conducted on eating behaviour and behaviour change (e.g. Hattar, Hagger, & Pal, 2015; Moffitt, Brinkworth, Noakes, & Mohr, 2012; Harris, Bargh, & Brownell, 2009; Wansink, Painter, & North, 2005). This study aims to contribute to and extend this literature by studying the potential of harnessing psychological principles on learning and conditioning to influence eating behaviour.

Much of this research has focused on changing eating behaviour by increasing food-related self-control (Johnson, Pratt, & Wardle, 2012), or attempting to give people the tools to consciously override ‘gut feelings’ and reactions – their implicit food evaluations (de Houwer, Gawronski, & Barnes-Holmes, 2013) – that cause them to regularly overeat (e.g. Hattar, Hagger, & Pal, 2015). Implicit food evaluations are thoughts or feelings automatically associated with specific food items, which influence one’s liking of these foods (Walsh & Kiviniemi, 2014). While consciously trying to override implicit evaluations leading to harmful food choices can indeed lead to improved eating habits (Adriaanse, Vinkers, de Ridder, Hox, & de Wit, 2011), this may not be the best way to counter overeating (Hofmann, Friese, & Wiers, 2009). Intuitively it would be easier if, instead of having to battle your gut feelings constantly in order to eat more healthily, these gut feelings told you to eat healthy food. This idea, combined with the fact that eating is thought to be a primarily automatic and habitual behaviour governed by these automatic signals (Cohen & Babey, 2012; Naughton, McCarthy, & McCarthy, 2015), is why more recently research has also focused on trying to change eating behaviour by actively targeting and altering implicit evaluations. This approach has generated some positive results in the health behaviour domain (Wiers, Rinck, Kordts, Houben, & Strack, 2010; but see Becker, Jostmann, Wiers, & Holland, 2015) and involves harnessing valence information to alter the implicit value of a given food category by association, for example by associating healthy food with positively-valenced stimuli. This associative procedure has proven especially useful for people who generally exhibit low self-control, because the barrier between their implicit food evaluations and their actual food consumption is low, meaning that they are quick to put impulse to action (Haynes, Kemps, & Moffitt, 2015). Thus, because their implicit evaluations of different foods are a good predictor of actual eating behaviour (Ellis, Kiviniemi, & Cook-Cottone, 2014), changing their implicit evaluations of healthy and unhealthy foods could lead to a decrease in unhealthy eating, with a resulting decrease in obesity. This evaluative conditioning may be much more effective than attempts to alter food choice through conscious, deliberative routes (Hofmann et al., 2009). The aim of this study was to likewise change people's implicit food evaluations to bring about a change in eating behaviour.

1.1 Evaluative conditioning

One way in which researchers have tried to influence people's implicit food evaluations is through evaluative conditioning (EC). The EC procedure consists of the consistent pairing of a conditioned stimulus (CS), which initially is neutrally valenced, with an unconditioned stimulus (US), which is positively or negatively valenced, to change one's implicit evaluations of the CS (Walsh & Kiviniemi, 2014; de Houwer, Thomas, & Baeyens, 2001; Hofmann, Perugini, de Houwer, & Baeyens, 2010; Levey & Martin, 1975). Previous studies have shown that the EC procedure can indeed be employed successfully to change one's liking of a specific stimulus, which is called 'the EC effect' throughout this article (Dwyer, Jarratt, & Dick, 2007; see Hofmann et al., 2010, for a review). For instance, many studies have shown that pairing healthy food with positive stimuli and unhealthy food with negative stimuli can prompt one to like healthy food more and unhealthy food less, and vice versa (e.g. Lebens, Roefs, Martijn, Houben, Nederkoord, & Jansen, 2011; Walsh & Kiviniemi, 2014; Hollands, Marteau, & Prestwich, 2011). An influence of EC tasks on eating behaviour is less well supported. While some studies have found that EC tasks can affect food choice in the lab (Walsh & Kiviniemi, 2014; Hollands et al., 2011), others fail to observe any such influence (Lebens et al., 2011). In short, although the evidence for an EC effect on implicit evaluations is quite strong, the evidence for an EC effect on explicit food choice is conflicting. Therefore, the purpose of this study was to investigate the relationship between implicit and explicit measures by investigating whether an EC task affects explicit eating behaviour by changing implicit food evaluations (that is, through a mediation effect of implicit evaluations of food on explicit food choice). This is an important question, because should it be the case that a change in implicit food evaluations mediates the effect of the EC task on food choice, this would mean that food choice is altered through an automatic, non-cognitive mechanism. This would make targeting implicit, rather than explicit, processes a potential avenue for behaviour change, circumventing the inconsistencies and difficulties associated with nutritional behaviour change through explicit processes.

Hollands, Marteau and Prestwich (2011) tried to address this question of mediation. However, their study paired food stimuli with positively and negatively valenced body images, which is problematic. Firstly, one's implicit evaluations of body images are not necessarily intrinsic; studies have shown that multiple factors, including peer pressure, maternal influence and media exposure, affect how negatively one evaluates overweight or obese bodies (Stice, 1998). Thus, people's cognitive, emotional and affective relationship with body images is a complex one, and not unambiguously positive or negative (Lascelles, Field, & Davey, 2003). Secondly, one's evaluation of different body images are likely linked with several food- and health-related beliefs and attitudes, making body USs and food CSs interdependent prior to the experiment, which may reduce US effectiveness. To overcome these problems, the current study used happy and angry faces as USs. Humans arguably have an intrinsic preference for happy faces over angry faces (Kim & Johnson, 2013; D'Entremont & Muir, 1999), without prior association with food. In addition, because virtually everyone regularly encounters faces in their everyday environment, one might sooner assume that no one has especially strong, unique associations with faces compared to other people. Using highly valenced non-human pictures (e.g. a train wreck) that might not be so common makes it much more likely that some but not all participants have particular associations with one or more of the images, leading to larger individual differences in image valence. To avoid these larger individual differences in image valence, happy and angry faces were chosen over other images that might have a stronger valence but that might also be more ambiguous and thus generate greater individual differences. This use of stimuli with an unambiguous affective valence and without pre-existing associations with food or significant life events uniquely contributes to the literature on the effect of an EC task on food choice and the mediating role of implicit food evaluations herein.

1.2 Contingency awareness, EC task attention and pre-existing eating habits

To maximise sensitivity of detection of EC effects, we took into account cognitive factors theorised to influence the EC effect. A meta-analysis by Hofmann et al. (2010) has shown that EC tasks can generate much stronger effect sizes when participants are aware of the CS-US pairings. To be able to statistically control for these factors, if necessary, contingency awareness was measured in this study and a moderation analysis was run to see if it influenced the effect of the EC task. It was hypothesised that those who were contingency aware would experience a greater shift in preference than those who were contingency unaware. Another suggested influence on EC effect size is how much attention participants pay to the EC task (Gast & Rothermund, 2011; Walsh & Kiviniemi, 2014). To also be able to control for attention, if necessary, EC task accuracy was measured as an index of attention paid to the task. It was hypothesised that participants with high accuracy scores, and thus high task attention, would also experience a greater shift in preference towards the conditioned category. Lastly, pre-existing eating habits (i.e. fruit and vegetable intake in the last 30 days, and restrained, external and emotional eating) were measured, because several eating practices can influence implicit food liking and food choice (de Bruijn, Keer, Conner, & Rhodes, 2011; Hoefling & Strack, 2008; Houben, Roefs & Jansen, 2012). These three factors were included because they have been found to influence the effects of the EC procedure and because they allowed us to account for the modulation of the conditioning process by these factors. It is, however, beyond the scope of this study to investigate the exact role they play in the conditioning process.

1.3 The current study

In summary, the main aim of this study was to see whether healthy and unhealthy food choice can be influenced using an evaluative conditioning procedure, and whether implicit food evaluations is a mediating factor in food choice. Factors related to food choice (restrained, external and emotional eating, and habitual fruit and vegetable intake) and the EC effect size (e.g. contingency awareness and task attention) were measured in order to be able to control for them. In light of the prior research, we hypothesised that 1) participants in the EC condition that paired healthy foods with happy faces and unhealthy foods with angry faces (the *healthy* condition) will have a stronger positive implicit evaluation of healthy food than will participants in the EC condition that paired unhealthy food with happy faces and healthy food with angry faces (the *unhealthy* condition); 2) Participants in the *healthy* EC condition will choose healthy foods more often in an explicit food decision-making task than will participants in the *unhealthy* EC condition; 3) The effect of EC condition on explicit food choice will be mediated by implicit food evaluations; 4) The EC effect will be stronger for contingency aware participants than for unaware participants; 5) The EC effect will be stronger for participants with higher EC task attention. As previous research has found such conflicting results concerning the effect of EC on food choice and the role of implicit evaluations, this study contributes to the understanding of the constraints of the EC effect and the differential mechanisms underlying implicit and explicit measures.

2. Methods

2.1 Participants

95 participants (70 females) between the ages of 18 and 54 years (*M*=24.88 years, *SD*=6.16 years) participated in the study. An a priori power analysis showed that to observe a medium effect size of d=0.52 (informed by Hofmann et al., 2010), approximately 50 participants per condition were required. The participants were recruited via an online recruitment system or convenience sampling and were paid £5 (or the equivalent in course credit) plus a snack for their participation. Participants were randomly assigned, 47 to the *healthy* EC condition and 48 to the *unhealthy* EC condition. Except for restrained eating score, which was higher in the *healthy* condition (*M*=2.49, *SD*=0.71) than the *unhealthy* condition (*M*=2.16, *SD*=0.76; $t(93)=2.14$, $p=.04$), there were no significant differences between the two conditions on demographic and pre-screen variables (see Table 1 for a comparison between the two conditions on all variables). All procedures were non-invasive, and received ethical approval from the UCL Department of Experimental Psychology Ethics Chair (CPB/2013/004). Participants provided written consent before commencement. None of the participants were excluded from data analysis.

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2.2 Procedure

A week before the participants came to do the experiment, they filled out a questionnaire at home, consisting of questions on demographics (age, gender, ethnicity, education level, height and weight), the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986) to measure their eating behaviour, and the National Cancer Institute (NCI) Quick Food Scan (Subar et al., 2001) to measure their fruit and vegetable intake. Pre-existing eating habits were measured to examine them as covariates, since eating practices such as restrained eating can influence implicit food liking and food choice (de Bruijn et al., 2011; Hoefling & Strack, 2008; Houben et al., 2012). The questionnaire order was counterbalanced as to whether participants filled out the DEBQ or the NCI survey first.

Upon coming into the lab, all participants read an information sheet and filled out a consent form. They were informed that they would be doing three computer tasks, programmed and delivered with MATLAB R2014a, v. 8.3 (MathWorks, 2014), using the Psychophysics Toolbox (Brainard, 1997) on a Dell personal computer with a screen size of 19.1” and a resolution of 1600x900. The participants were also told that they would have to fill out a short questionnaire at the end of the experiment. All participants, seated approximately 80 centimetres from the screen, started with the EC task. The EC task was followed by the Implicit Association Task (IAT) and a decision-making task. The order of the IAT and decision-making task was counterbalanced across participants. The order in which the IAT and the decision-making task were performed did not correlate significantly with either the score on the IAT ($r<.01$, $p=1.00$) or the percentage of healthy food choices ($r=.08$, $p=.43$).

Finally, participants filled out a short manipulation check questionnaire. This consisted of two contingency awareness questions. The first asked whether they noticed anything about the order of the stimuli in the EC task, to see whether they could recall the order without any prompting. The second question was a multiple choice question in which participants had to indicate which pairings (healthy-happy, unhealthy-angry, unhealthy-happy, healthy-angry, or none) had occurred in their EC task. This question was asked to see whether they could recognise the pairings when prompted. Participants scored 0 on contingency awareness if they did not recall or recognise the right pairings. They scored 1 if they recognised the pairings in their condition after having been prompted, and 2 if they had noticed the correct pairings without having been prompted. These initial questions were followed by questions about whether they knew what an IAT was and whether they had performed one before, and how many hours it had been since they last ate. This last question was included because all participants had been asked to refrain from eating in the three hours before the experiment. This final question allowed us to check whether participants actually followed this rule and to determine whether participants in both conditions had refrained from eating for a similar amount of time prior to the experiment, since differing hunger levels could influence desire for either healthy or unhealthy foods. Participants were then given a snack and were debriefed.

2.3 Measures and materials

2.3.1 DEBQ

The DEBQ (van Strien et al., 1986) consists of 33 questions, divided into three subscales: restrained eating, emotional eating and external eating. The restrained eating subscale consists of ten questions and measures to what extent participants are chronic dieters (e.g. “Do you watch exactly what you eat?”). The emotional eating subscale consists of 13 questions and measures to what extent the participants’ eating behaviour is influenced by their emotional states (e.g. “Do you have a desire to eat when you are anxious, worried or tense?”). The external eating subscale consists of ten questions and estimates to what degree the participants’ eating behaviour is determined by whether food is present or not (e.g. “If you see others eating, do you have a desire to eat?”). All questions were answered on a five-point Likert scale (1=never to 5=very often). All subscales showed excellent reliability ($\alpha=.88$, $\alpha=.94$, $\alpha=.80$, respectively). The subscales were used separately in the analyses – no composite score of the DEBQ was used.

2.3.2 NCI survey

The NCI survey (Subar et al., 2001) measures whether participants reach their ‘five a day’ with regard to fruit and vegetable consumption. Participants answered questions about their consumption of ten types of food that add to one’s daily fruit and vegetable consumption over the last month. For each type of food, they commented on how often they ate it, and if they ate it, how big their usual serving was. These answers were used to calculate a score for each participant indicating how many servings of fruit and vegetables they tend to eat on an average day.

2.3.3 EC task

The EC task (adapted from Walsh & Kiviniemi, 2014) consisted of 120 trials during which an image (a food, face, or neutral object) was presented, which on half of the trials was accompanied by a grey dot in a random location. The participants were told that their task was to press the spacebar upon seeing the dot. Between trials, they had to keep their eyes on a fixation cross at the centre of the screen. A food picture (CS) was always followed by a picture of a face (US). In the *healthy* condition, healthy foods were followed by happy faces and unhealthy foods by angry faces. In the *unhealthy* condition, this was reversed, such that healthy foods were followed by angry faces and unhealthy foods by happy faces. Due to limited resources, no neutral condition was included.

Each trial consisted of the presentation of one stimulus for 1000 ms, followed by 1000 ms of fixation before the next trial began. 12 pictures each of neutral objects (e.g. a pair of scissors), healthy foods (e.g. an apple), unhealthy foods (e.g. a cookie) were used, comprising a total of 36 unique stimuli. Each stimulus was presented twice, and all the food images were followed by a face, resulting in 120 trials in total. To select the food images to be used in the EC task, 33 images of healthy foods and 33 images of unhealthy foods were taken from the internet and piloted for perceived tastiness (five-point Likert scale, 1=very unappetising to 5=very tasty) and healthiness (five-point Likert scale, 1=very unhealthy to 5=very healthy). They were piloted on a separate sample of 50 people (41 women; age range 18 to 28 years (M=20.48 years, SD=2.19 years). Out of all the pictures, 12 unhealthy and 12 healthy pictures were chosen based on healthiness and taste. Since the CSs are supposed to be previously neutral stimuli, and because it is still unclear whether an EC task can also change attitudes towards a CS that is already either positively or negatively valenced, all images chosen for this task were neutrally rated on taste (healthy items: M=3.20, SD=0.24; unhealthy items: M=3.12, SD=0.39). Out of all items that were neutrally rated on taste, the 12 healthiest (M=4.26, SD=0.16; e.g. celery) and 12 unhealthiest were chosen (M=1.86, SD=0.26; e.g. muffin). A t-test revealed no significant differences in taste rating between the healthy and the unhealthy items included in the task ($t(22)=0.57$, $p>.05$). Images of six happy and six angry faces were used, each being presented four times in the course of the conditioning task. The images were taken from the NimStim database (Tottenham et al., 2009). The same people (three men and three women) were depicted in the happy and the angry pictures. To remove part of the bias due to attractiveness and the effects of low-level visual differences, the images were cropped so only the face (and not the hair, neck and ears) were shown. The creators of the database from which the pictures were taken have previously shown that the emotions in the pictures were identified with high validity and acceptable reliability, especially the positively valenced faces (Tottenham et al., 2009), and thus the images were not piloted. All images were made the same size (400x400 pixels) and converted to grey-scale to control for any size and colour biases. The task differs from the one used by Walsh and Kiviniemi (2014) because they only used fruits as healthy stimuli, while this task used a broader range of healthy items (including vegetables) in order to investigate the generalisability to other stimuli within a given semantic category, rather than stimulus-specific EC. Studying generalisability is important because greater generalisability would provide the foundation for a more effective real-world intervention.

2.3.4 IAT

The IAT was used to measure participants' implicit food evaluations. It consisted of seven blocks (three practise blocks and four data collection blocks). During each trial, a word was presented which the participant had to sort into a category, which was either (1) pleasant words, (2) unpleasant words, (3) healthy foods, (4) unhealthy foods. Practice blocks consisted of 40 trials each. In these blocks, participants always had to sort either food words or emotion words, but never both at the same time (see Fig. 1). Data collection blocks contained 80 trials each, because all stimuli were presented during these blocks (see Greenwald, McGhee, & Schwartz, 1998, for a full description of the IAT). Participants sorted words to the left by pressing 'z' and to the right by pressing '/'. A trial was marked as an 'error' if the participant initially sorted a word to the wrong side, even though they corrected their answer after receiving feedback. A positive score, meaning that participants were faster sorting the healthy and pleasant words to one side and unhealthy and unpleasant to the other rather than vice versa, indicates a general implicit preference for healthy food; a negative score indicates a general implicit preference for unhealthy food. The higher the absolute score, the stronger the preference. Scores were based on data collection blocks only.

INSERT FIGURE 1

The pleasant and unpleasant words were taken from a study by Greenwald and Farham (2000). 34 of each word type were piloted. The pilot subjects (13 people: 9 females; age range 19–58 years (*M*=38.46 years, *SD*=16.81 years)) were asked to rate all the words according to how pleasant they found them (five-point Likert scale, 1=very unpleasant to 5=very pleasant).The 20 words rated most pleasant (*M*=4.40, *SD*=0.14) and the 20 words rated most unpleasant (*M*=1.64, *SD*=0.21) were chosen. The food words (34 healthy and 34 unhealthy) were also piloted (21 people: 14 females; age range 19–58 years (*M*=33.33 years, *SD*=16.03 years)). They were rated for healthiness (five-point Likert scale, 1=very unhealthy to 5=very healthy) and tastiness (five-point Likert scale, 1=very unappetising to 5=very tasty). Out of all food words, the 20 rated healthiest (*M*=4.52, *SD*=0.18) and the 20 rated unhealthiest (*M*=1.63, *SD*=0.26) were chosen. The perceived tastiness of the healthy (*M*=3.94, *SD*=0.45) and unhealthy (*M*=4.05, *SD*=0.36) food words did not significantly differ from each other ($t(38)=0.88$, $p=.38$).

Several studies have shown that unless a very small (i.e. <5) number of stimuli is used, the number of trials does not seem to influence the magnitude of the IAT score (Nosek, Greenwald, & Banaji, 2005; Greenwald et al., 1998). Therefore, it was decided to let the number of trials depend on how many of the piloted words fit the aforementioned criteria, meaning they were matched for tastiness but strongly valenced in terms of health value. This resulted in the use of 20 healthy and 20 unhealthy words and 20 pleasant and 20 unpleasant words, meaning that there were 40 trials in each practice block and 80 in each data collection block. Each trial ended when the participant pressed the correct answer, so trials varied in length. However, the inter-trial interval was always 500ms, and pre-stimulus fixation time always 1000ms (Greenwald et al., 1998). The task was counterbalanced so that half of the participants started by sorting healthy and pleasant words to one side, and unhealthy and unpleasant words to the other side, with the other half starting by sorting unhealthy and pleasant to one side, and healthy and unpleasant words to the other side. This procedure was used to control for order effects, since it has been shown that one's IAT score tends to be skewed towards the combinations of categories that are sorted to the same side first (Greenwald, Nosek, & Banaji, 2003). Indeed, in this study, starting the IAT by sorting the healthy words and the pleasant words to one side and unhealthy and unpleasant words to the other side was strongly positively correlated with participants' overall score on the IAT, and vice versa ($r=.46$, $p<.001$).

2.3.5 IAT data pre-processing

Following the procedures of Greenwald et al. (2003), all trials with a reaction time below 400 ms or above 10,000 ms were removed from analysis. This operation has previously been shown to strike a good balance between optimising the IAT effect size and reducing the correlation of the IAT score with average latency (Greenwald et al., 2003). An average of 0.07% of trials per participant was excluded (range: 0.00-2.81%). This percentage did not differ significantly between conditions ($t(93)=0.58$, $p=.57$). Also, since many participants commented that the unhealthy word 'apple pie' was confusing to sort, as it starts with the healthy word 'apple', IAT scores were calculated without the 'apple pie' trials (meaning that an additional four trials for every participant was excluded). IAT scores were calculated by subtracting the average reaction time on blocks where healthy/happy and unhealthy/angry had to be sorted together from the average reaction time on blocks where healthy/angry, and unhealthy/happy had to be sorted together. The resulting score was divided by the pooled standard deviation. No participants were excluded due to error rates on the IAT.

2.3.6 Decision-making task

To measure explicit food choice, participants completed a 22-trial forced-choice decision task (see Fig. 2). On each trial, two food images were presented, one healthy and one unhealthy, and participants were required to choose which of the two they would most like to receive, while prompted to keep in mind that one of their food choices, on a randomly selected trial, would be received on completion of the experiment. This was to motivate them to answer honestly, guided by their true preferences. This task was used to obtain a more powerful and balanced measure of food choice by taking an aggregate of a number of choices, as opposed to the single choice between (a range of) healthy and unhealthy foods used in prior studies (e.g. Walsh & Kiviniemi, 2014). The images were paired pseudo-randomly – the only constraint being that one had to be healthy and one unhealthy – and the participants could take as long they wanted to make each choice. The images in this task were selected from the same batch of piloted images from which those in the EC task were chosen. 11 healthy and 11 unhealthy foods were chosen for the decision-making task, and each image was used twice. These were images that were not used in the EC task because for an EC task to be used effectively to increase healthy eating, it is necessary that the evaluative transfer from the US to the CS transfers not only to that specific CS, but to the semantic class that the CS is a part of. Indeed, some previous studies have shown that it is possible for an EC task to not only transfer the valence of the US onto the specific CS presented in the task, but also to other stimuli within the class that the initial stimulus was a part of (Hütter, Kutzner, & Fiedler, 2014), and to other objects previously associated with the CS prior to the experiment (Walther, 2002), thus showing the generalisability of the EC effect. The images were chosen to span as big a range as possible on taste ratings to make the results more generalisable and not constrained to a small range of foods. The healthy images (e.g. pomegranate) were all rated between 3.30 and 4.54 on taste (M=3.80, SD=0.32); the unhealthy images (e.g. crisps) were rated between 2.76 and 4.30 (M=3.63, SD=0.55). Healthy and unhealthy images did not significantly differ in perceived tastiness ($t(20)=0.91$, $p>.05$). Pictures were only chosen for the healthy group if their health rating was above 3.5 on a five-point Likert scale (health range: 4.02 to 4.68; M=4.29, SD=0.23) and for the unhealthy group if their rating was below 2.5 on this same scale (health range: 1.56 to 2.36, M=1.91, SD=0.29). This was to ensure there were no images in the task that could be perceived as being of neutral healthiness (e.g. a granola bar, or dark chocolate). Image location was counterbalanced, such that healthy and unhealthy images each appeared on the left on 50% of the trials. Images in the decision-making task were not in grayscale. This particular food choice task was chosen because in order to know whether an EC procedure could realistically be used in therapy against unhealthy eating, it needs to be studied whether EC tasks have an effect on food choice even when the participant is aware that their food choice is monitored. To accomplish this, it was necessary that the participants were aware that their choices were recorded. After all, if an EC procedure would be used as part of a therapy to alter health behaviours, the point of the task would be very clear. The task would therefore be useless for therapeutic purposes if EC tasks only alter food choice if the participant is completely unaware that the two tasks are related.

INSERT FIGURE 2

2.4 Statistical analysis

All analyses were performed in SPSS v22 (IBM Corp., 2013). Two separate multiple linear regression models were used to test for the effect of the EC task on implicit food evaluations and explicit food choice (with EC condition as the main predictor and IAT score and decision-making task choices, respectively, as the dependent variables). Restrained eating was added as a covariate to these analyses because it differed between the two EC conditions. The possible mediation of implicit food evaluations of the effect of the EC task on explicit food choice was tested using multiple linear regression in the SPSS-macro PROCESS (Hayes, 2013), with EC condition as the predictor, implicit food evaluations as the mediator, and food choice as the outcome variable. Restrained eating was also added to the mediation model as a covariate. Then, to test for the possible influence of contingency awareness on the EC effect, two ANOVAs were run (one with implicit evaluations and one with food choice as the dependent variable), both with EC condition, contingency awareness and their interaction as separate predictors. The sample then was split according to contingency awareness (aware vs. unaware), and t-tests were run separately for each group to see whether implicit evaluations and food choice differed significantly between the two EC conditions. A chi-square was also done to see whether the rate of contingency awareness differed between the two EC conditions. To test for a possible moderating influence of EC task attention on the EC effect, two ANOVAs were run (one for each dependent variable), with EC condition, EC task accuracy (split high vs low), and their interaction as separate predictors. Again, the sample was split according to high and low attention and t-tests were done to see how the effect of the EC procedure on implicit evaluations and food choice differed between high and low attention participants. A t-test was done to see whether EC task attention differed between the two EC conditions.

3. Results

3.1 Data assumptions

According to the Shapiro-Wilk test of normality, both dependent variables (DVs) were distributed normally in both conditions (IAT score: Shapiro-Wilk(48)=0.95, *p*=.05 for the *unhealthy* condition and Shapiro-Wilk(47)=0.98, *p*=.64 for the *healthy* condition; food choices: Shapiro-Wilk(47)=0.97, *p*=.33 for the *unhealthy* condition and Shapiro-Wilk(47)=0.95, *p*=.06 for the *healthy* condition). The assumption of homoscedasticity was also met, as error plots showed no sign of heteroscedasticity. As for outliers, linear regression analyses with EC condition as predictor and food choice and IAT score as DVs showed that all studentised residuals were below |3|, that the highest Mahalanobis D was 1.01, the highest Cook's distance was 0.07, and all Leverage values were around 0.01. Since these numbers are all well within acceptable boundaries, there were no outliers that needed to be excluded from the data analysis.

3.2 Hypothesis 1: Effect of the EC task on implicit food evaluations.

A multiple linear regression, controlling for restrained eating (B=-0.013, *t*(92)=0.24, *p*=.81), was carried out to test the effect of the EC task on implicit food evaluations (R^2=0.05). EC condition was the predictor of interest and IAT score was the DV. This analysis showed a significant effect of EC condition on implicit food evaluations (B=0.17, *t*(92)=2.16, *p*=.033). Those assigned to the *healthy* condition (*M*=0.60, *SD*=0.32) scored significantly higher on the IAT compared to those in the *unhealthy* condition (*M*=0.43, *SD*=0.43; see Fig. 3), which reveals a stronger preference for healthy foods for those in the *healthy* condition (d=0.45). The model was also run with gender and fruit/vegetable intake as additional covariates, but neither were significant predictors and their inclusion did not alter the main effect. For the sake of parsimony, the model with restrained eating as the only covariate is reported.

INSERT FIGURE 3

3.3 Hypothesis 2: Effect of the EC task on explicit food choice

The same multiple linear regression as above was applied with explicit food choice as the DV (R^2=0.03). EC condition was not a significant predictor of food choice (B=0.036, *t*(92)=0.70, *p*=.49). Participants in the *healthy* condition *(M*=51.26%, *SD*=21.12%) did not choose a significantly higher percentage of healthy foods than those in the *unhealthy* condition (*M*=46.21%, *SD*=27.28%; d=0.21; see Fig. 4). Restrained eating was not a significant predictor of explicit food choice in this model (B=0.045, *t*(92)=1.32, *p*=.19). Again, the model was also run with gender and fruit/vegetable intake as additional covariates, but because their inclusion did not alter the main effect, the model with restrained eating as the only covariate is reported. However, in this alternative model, fruit and vegetable intake was a significant predictor of food choice ($B=0.028$, $t(90)=2.62$, $p=.010$); those who reported higher habitual fruit and vegetable intake on the NCI more often chose a healthy food over an unhealthy food.

INSERT FIGURE 4

3.4 Hypothesis 3: Mediation effect of the EC task on explicit food choice through implicit food evaluations

Since there was no direct effect of the EC task on explicit food choice, the mediation effect verbalised in hypothesis 3 should not be tested using the causal steps approach developed by Baron and Kenny (1986), for which a direct effect is one of the requirements, even though a multiple regression analysis did uncover that implicit food evaluations was a significant predictor of explicit food choice ($B=0.20$, $t(93)=3.13$, $p<.01$). However, some have argued that the causal steps approach to mediation is outdated and that a mediated, indirect effect can exist in the absence of a direct effect (Hayes, 2009). Therefore, mediation analysis was carried out using the SPSS macro PROCESS (Hayes, 2013), which can test for an indirect effect where no direct effect exists. This analysis revealed a significant indirect effect of the EC task on explicit food choice, mediated by implicit food evaluations ($B=0.03$, $CI=0.006, 0.08$), despite the absence of a direct effect of EC on food choice ($B=0.003$, $CD=-0.10, 0.10$).

INSERT FIGURE 5

3.5 Hypothesis 4: Moderation effect of contingency awareness on implicit food evaluations and explicit food choice

Two analyses of variance (ANOVAs; one for each dependent variable) were performed with the variables EC condition, contingency awareness and their interaction term (EC condition x contingency awareness) as the independent variables. The effect of the interaction term was not significant for either implicit food evaluations ($F(2, 89)=1.44$, $p=.24$) or food choice ($F(2, 89)=0.72$, $p=.49$), meaning that contingency awareness did not moderate the effect of the EC condition on implicit food evaluations or food choice. There was a main effect of EC condition for implicit food evaluations ($F(1, 89)=5.80$, $p=.018$) but not for food choice ($F(1, 89)=1.14$, $p=.29$). There was no main effect of contingency awareness for either outcome ($F(2, 89)=1.14$, $p=.33$ and $F(2, 89)=0.079$, $p=.92$, respectively). We consequently split the sample according to contingency awareness (aware, unware). It was found that for those who were not contingency aware, which was the overwhelming majority of the sample ($N=79$), there was no effect of the EC procedure on implicit food evaluations ($t(77)=1.36$, $p=.18$), while there was a significant difference between EC conditions on implicit food evaluations in those who were aware of the contingencies ($t(14)=2.49$, $p=.026$), even though only 16 participants were contingency aware. Those in the *healthy* condition had a much more positive implicit evaluation of healthy foods ($M=0.70$, $SD=0.28$) than those in the *unhealthy* condition ($M=0.26$, $SD=0.42$). Healthy food choices did not differ by EC condition for both those who were not contingency aware ($t(77)=0.43$, $p=.67$) and those who were contingency aware ($t(14)=1.99$, $p=.067$), although the effect in those who were contingency aware approached significance. In the case of those who were contingency aware, the participants in the *healthy* condition chose marginally more healthy foods (*M*=55.91%, *SD*=13.89%) than those in the *unhealthy* condition (*M*=37.12%, *SD*=24.29%). These findings combined cautiously suggest that conditioning may have had stronger effects in those who noticed the food-face pairings. The proportion of people who were contingency aware did not differ significantly between the two EC conditions ($\chi^2(2)=1.33$, $p=.51$).

3.6 Hypothesis 5: Moderation effect of EC task accuracy on implicit food evaluations and explicit food choice

EC task accuracy was calculated as the percentage of trials on which participants correctly identified the grey dot when it was presented. Across participants, accuracy ranged from 43.33% to 95.83% (M=86.13%, SD=7.85%). A median split (at 88.33%) was performed to separate the participants into those with high and low task accuracy. Two ANOVAs (one for each outcome variable) were performed with the variables EC condition, EC task accuracy and their interaction term (EC condition x EC task accuracy) as the independent variables. Again, there was no significant interaction term for implicit food evaluations ($F(1, 91)=0.092$, $p=.76$) or explicit food choice ($F(1, 91)=0.17$, $p=.69$). There was a marginally significant main effect of EC condition on implicit food evaluations ($F(1, 91)=3.95$, $p=.050$), but not on food choice ($F(1, 91)=0.69$, $p=.41$). Thus the extent to which participants paid attention to the EC task did not affect the strength of the EC effect. There was no significant difference in EC accuracy between the two conditions ($t(93)=1.58$, $p=.12$). Splitting the sample according to EC task awareness did not show any differing EC effects between the high-accuracy and low-accuracy participants (*p*s>.05).

3.7 Post-hoc analysis

To explain the null-result regarding the EC effect of task accuracy on implicit food evaluations and explicit food choice, an exploratory correlation analysis was carried out, which revealed a significant negative correlation between EC task accuracy and contingency awareness ($r=-0.20$, $p<.05$), meaning that the more participants focused on spotting the dot on the EC task, the worse their recall was for food and face pairings in that same task. Additional interaction ANOVAs were also conducted to see if any of the subscales of the DEBQ or habitual fruit and vegetable intake had a moderating influence of the EC effect on food choice, to explain the null-result across the whole sample. There was no interaction of EC condition and habitual fruit/vegetable intake on food choice ($F(1, 91)=0.48$, $p=.49$). There was also no interaction with restrained eating ($F(1, 91)=0.002$, $p=.96$) or external eating ($F(1, 91)=0.85$, $p=.36$). However, an interaction effect was found between EC condition and emotional eating ($F(1, 91)=4.95$, $p=.029$).

Performing the interaction analysis with a median split of emotional eating (which was also significant: F(1, 90)=6.37, p=.013), it was found that the EC effect was only present in those scoring low on emotional eating (see Figure 5). In the *healthy* condition, low emotional eaters chose healthy foods on 59.6% (*SD*=24.3%) of trials, while in the *unhealthy* condition they chose healthy foods on 41.6% (*SD*=25.3%) of the trials. This difference was significant (*t*(45)=2.44, *p*=.019). The high emotional eaters chose healthy foods only 45.6% (*SD*=16.9%) of the time in the *healthy* condition, while in the *unhealthy* condition, they chose healthy foods on 52.7% (*SD*=29.3%) of the trials, which was not significantly different (*t*(46)=0.29, *p*=.29). This mirrored the findings on implicit food evaluations. For the low emotional eaters, the implicit evaluation of healthy food was significantly more positive in the *healthy* condition (*M*=0.65, *SD*=0.34) than in the *unhealthy* condition (*M*=0.42, *SD*=0.40; *t*(45)=2.10, *p*=.042). For those scoring high on emotional eating, the implicit evaluation of healthy food was not significantly more positive in the *healthy* condition (*M*=0.56, *SD*=0.31) than in the *unhealthy* condition (*M*=0.46, *SD*=0.48; *t*(45)=0.85, *p*=.40).

INSERT FIGURE 6

4. Discussion

The main aim of this study was to investigate whether an EC task can change one's implicit evaluations of healthy and unhealthy foods, whether it can change actual food choice, and whether the change in implicit evaluations mediates the change in food choice. Participants in the *healthy* condition did have a significantly stronger preference for healthy food than participants in the *unhealthy* condition. This study therefore supports the proposition that implicit evaluations within the nutrition domain can be changed with an EC procedure (Walsh & Kiviniemi, 2014; Lebens et al., 2011; Hollands et al., 2011; Dwyer et al., 2007).

However, no effect of the EC task on explicit food choice was found for the whole sample. While explicit food choice was significantly predicted by implicit food evaluations – which were, in turn, significantly affected by the EC task – there was no difference in the percentage of healthy foods chosen during the decision-making task between EC conditions. This is consistent with Lebens and colleagues (2011), who also found no effect of the EC task on food choice, but runs counter to the findings of Walsh and Kiviniemi (2014) who found that the participants in their *healthy* condition were three times more likely to choose a piece of fruit over a granola bar than the participants in their *unhealthy* condition. This may be due to methodological differences between this study and that of Walsh and Kiviniemi (2014). In particular, in their study, the same fruit items were used as both CSs and choice options, while in the current study none of the food choice options in the decision-making task had been used in the EC task. While it has been shown that pairing a previously neutral CS with a valenced US can make the valence of the US transfer to other objects previously associated with or in the same semantic domain as the CS (Walther, 2002; Hütter et al., 2014), it may be the case that the EC effect is stronger for the specific CS conditioned during the EC task (as in Walsh and Kiviniemi's study), and weaker for those conditioned by generalisation from the CS (as in our study). On top of that, Walsh and Kiviniemi did not offer a choice between a very healthy and a very unhealthy food item, but between a piece of fruit and a granola bar, which according to the pilot data of this study might generally be considered to be neutral, not unhealthy. Hence, it may be that the difference in health properties between the two food items may affect the EC effect on food choice – the larger the difference in healthiness between the two items, the harder it might be to prompt someone to choose one item over the other.

Despite the absence of a direct effect of the EC task on food choice, there was a significant indirect effect on food choice, mediated by implicit food evaluations. This finding partly confirms the results of Hollands et al. (2011), who also found an indirect effect of EC on food choice, mediated by implicit food evaluations. However, they also found a direct effect of the EC task on food choice for the whole sample, which was not the case in the current study. Our indirect effect also converges with previous findings that implicit food evaluations are a good predictor of actual food choice (Ellis et al., 2014; de Bruijn et al., 2011). However, the current mediation effect was established only by using a statistical mediation analysis. A causal link can therefore not be established. To establish a causal link, future studies might directly manipulate implicit food evaluations to see whether this affects food choice.

A possible explanation for the fact that no direct EC effect on food choice was found for the whole sample is that even though participants were made to implicitly prefer healthy or unhealthy food, they were perhaps too governed by their habitual eating behaviours for the EC task to have a real effect on their food choices. This explanation is supported by the fact that NCI score, which measures average fruit and vegetable intake and thus pre-existing eating habits, was the only significant predictor of explicit food choice. This is supported by other studies which have shown that prior eating habits are the strongest predictors of future eating behaviour (Naughton et al., 2015). However, eating behaviour, like restrained and external eating, did not moderate the effect of the EC task and food choice. Surprisingly, the results showed that an interaction effect did exist between the EC task and emotional eating. The EC task affected both implicit food evaluations and food choice as was hypothesised for those low in emotional eating, but no effect of the EC task on either outcome variable was found for those high in emotional eating. Given that emotional eaters tend to eat high-calorie, highly palatable foods, which induce the release of opioids in the brain (Mercer & Holder, 1997), they may have an especially strong emotional association with food, and unhealthy food in particular. Indeed, there is convincing evidence that emotional eaters have a heightened cognitive bias towards food cues (Brignell et al., 2009), which means that the food CSs were likely less neutrally valenced prior to conditioning for the high compared to the low emotional eaters. Since it is still unclear if an EC task can effectively be used to condition CSs that already have a positive or negative valence, this prior valence may have interfered with the EC task, thus leading to the absence of a change in implicit food evaluations and food choice among people scoring high on emotional eating. To the authors' knowledge, no studies have been performed testing the moderating influence of emotional eating on the EC effect; thus, the current study presents a distinctly novel finding, and replication of this finding is necessary. Future studies could also explore the effects of emotional eating on the EC task further, perhaps by specifically targeting populations that score particularly high or low on emotional eating.

Another way to produce a more powerful conditioning procedure might be to use more evocative images, especially when trying to reduce one's liking for unhealthy food. The unhealthy food images could for instance be paired with USs that induce disgust. Disgust is arguably a stronger, more visceral emotion than anger, so it might serve to better change actual food choice. On top of that, recent results suggest that the valence that the CS acquires by being paired with a disgusting US is resistant to extinction (Engelhard et al., 2014). This particular study did not use food CSs, but the findings regarding extinction may nevertheless indicate that pairing food CSs with disgusting

USs has the potential to change eating behaviour in the long term. However, one caveat that needs to be considered is the fact that a previous study has suggested participants need to be contingency aware for an EC procedure with highly evocative images to work (Jones, Fazio, & Olson, 2009). On the other hand, mildly evocative images (like the faces used in this study) as opposed to strongly evocative images have been found in the same study to produce a stronger EC effect for those who were not contingency aware (Jones, Fazio, & Olson, 2009). Therefore, should disgusting USs be used in future studies, it is important that the participants are made aware of the contingencies.

In this study, contingency awareness did not moderate the EC effect on implicit food evaluations or explicit food choice. However, when the sample was split up according to contingency awareness the results showed that the finding that the EC task influences implicit food evaluations only held for the participants who were contingency aware, and not for those who were contingency unaware. This finding seems to cautiously support the findings of a meta-analysis by Hofmann and colleagues (2010), who found that EC tasks generally have a bigger effect on those who are contingency aware than on those who are not, although in this study only a small number of participants were actually aware of the contingencies (n=10 in the *healthy* condition and n=6 in the *unhealthy* condition). However, contingency awareness was not systematically varied in this study. Future studies might provide stronger evidence for a positive effect of contingency awareness by manipulating contingency awareness directly.

Participants' attention to the EC task also did not moderate the EC effects on implicit evaluations or food choice. This null outcome contradicts two previous studies, which found that greater focus during the EC task increased EC effect size (Gast & Rothermund, 2011; Walsh & Kiviniemi, 2014). One possible explanation could be that in our study some participants were so focused on maximising task accuracy that they did not pay attention to the identity of the pictures, and thus did not experience the full EC effect. This hypothesis is consistent with the low rate of contingency awareness and the significant negative correlation between EC task accuracy and contingency awareness (Hofmann et al., 2010). However, for full support of this explanation by the data, one would also have expected the moderation analysis to show that higher accuracy negatively affects the strength of the EC effect. Since the overwhelming majority (86 out of 95) of the participants scored at least 80% accuracy on the EC task, there may not have been sufficient participants with a low enough accuracy in this study to meaningfully test the influence of EC task accuracy on EC effect size. A previous study has also suggested that mere stimulus focus, in the absence of a focus on the contingencies, is not sufficient for the EC effect to occur (Kattner, 2012). It is therefore likely that the nature of EC task focus is of vital importance. In our study, greater focus on the EC task may have been detrimental to the conditioning procedure by detracting from stimulus pairing detection. In future studies, it could be beneficial to replace the dot detection task with a task in which participants are explicitly instructed to attend to the images or to the contingencies, such as for a subsequent memory test. This might increase attention to the specific content of the images, and potentially also increase contingency awareness. While Walsh and Kiviniemi (2014) also did not ask their participants to focus on the specific CS-US pairings, they did ask them to pay attention to the stimuli presented and press the spacebar whenever an image of a specific category (e.g. “dessert foods”) came up. This heightened attention to the actual stimuli may have facilitated appearance of the EC effect and would also explain why they generally found larger effect sizes than were found in the current study.

Limitations need to be discussed with regard to the experimental paradigm. The main limitation of this study was that the healthy and unhealthy images used in the food decision-making task were not matched for portion size, calorie content, or fat and sugar levels. This omission could have influenced participants’ food choice. Even though they were instructed not to take portion size into account, participants may have used this to guide their choice of snacks. Since portion size was not measured, there is no way of knowing to what extent this affected the results. Future studies could obviate this problem by matching healthy and unhealthy snacks for portion size in the food decision-making task. However, should random pairing be preferred, another solution would be to record the amount of calories per snack and later check whether this is correlated with food choice in order to control for it during data analysis, if necessary. For future studies adopting a similar food choice paradigm, it might also be helpful to have the participants not only choose between healthy and unhealthy foods but have them rate the foods on tastiness/appeal. While the EC task might have increased preference for healthy food, for example, the increase may not have been of sufficient magnitude to override choice of particularly highly-valued food items in the other food category. This outcome would account for the significant effect of EC condition on implicit food evaluations but not on food choice. Assessing tastiness or appeal could help to provide evidence for such a process. Finally, this study did not include a neutral condition. We therefore cannot determine, based on the current results, whether a difference in implicit food evaluations and food choice between conditions occurred because healthy foods became more appealing, because unhealthy foods became less appealing, or because a combination of both effects occurred.

5. Conclusion

This study investigated the effect of an EC task on implicit evaluations of and explicit choice between healthy and unhealthy foods. The results of the current study support the idea that an EC task can change implicit food evaluations and food choice, but only in those participants who score low on emotional eating. This finding is novel in the domain of food-related EC and is a promising first step for behaviour change in the nutritional domain. However, why the EC task might only work for those who score low on emotional eating is still unclear and needs to be studied more extensively in order to identify the constraints of the applicability of an EC task to target unhealthy food choices. This study also showed that the EC task targets food choice through a change in implicit food evaluations. Uncovering the mechanism by which implicit food evaluations influence explicit food choice allows the EC effect to be harnessed for overt behaviour change. Knowing that food choice can be changed in the laboratory using an EC task, it would be useful for future studies to look into the effect of EC tasks on eating behaviour in a naturalistic setting to bridge the gap between basic research on EC and actual application of this procedure to target problematic eating behaviour.

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Conflict of interest

The authors declare no conflict of interest.

References

Adriaanse, M. A., Vinkers, C. D., de Ridder, D. T., Hox, J. J., & de Wit, J. B. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite, 56*(1), 183-193.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.

Becker, D., & Jostmann, N. B., Wiers, R. W., & Holland, R. W. (2015). Approach avoidance training in the eating domain: Testing the effectiveness across three single session studies. *Appetite, 85*, 58-65.

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision, 10,* 433-436.

Brignell, C., Griffiths, T., Bradley, B. P., & Mogg, K. (2009). Attentional and approach biases for pictorial food cues. Influence of external eating. *Appetite, 52,* 299-306.

Carr, D., & Friedman, M. A. (2005). Is obesity stigmatizing? Body weight, perceived discrimination, and psychological well-being in the United States. *Journal of Health and Social Behavior, 46*(3), 244-259.

Cohen, D. A., & Babey, S. H. (2012). Contextual influences on eating behaviors: Heuristic processing and dietary choices. *Obesity Reviews, 13*(9), 766-779.

D'Entremont, B., & Muir, D. (1999). Infant responses to adult happy and sad vocal and facial expressions during face-to-face interactions. *Infant Behavior & Development, 22*(4), 527-539.

de Bruijn, G.-J., Keer, M., Conner, M., & Rhodes, R. E. (2011). Using implicit associations towards fruit consumption to understand fruit consumption behaviour and habit strength relationships. *Journal of Health Psychology, 17*(4), 479-489.

de Houwer, J., Gawronski, B., & Barnes-Holmes, D. (2013). A functional-cognitive framework for attitude research. *European Review of Social Psychology, 24*(1), 252-287.

de Houwer, J., Thomas, R., & Baeyens, F. (2001). Associative learning of likes and dislikes: A review of 25 years of research on human evaluative conditioning. *Psychological Bulletin, 127*(6), 853-869.

Dwyer, D. M., Jarratt, F., & Dick, K. (2007). Evaluative conditioning with foods as CSs and body shapes as USs: No evidence for sex differences, extinction, or overshadowing. *Cognition & Emotion, 21*(2), 281-299.

Ellis, E. M., Kiviniemi, M. T., & Cook-Cottone, C. (2014). Implicit affective associations predict snack choice for those with low, but not high levels of eating disorder symptomatology. *Appetite, 77C*, 122-130.

Engelhard, I. M., Leer, A., Lange, E., & Olatunji, B. O. (2014). Shaking that icky feeling: Effects of extinction and counterconditioning on disgust-related evaluative learning. *Behavior Therapy, 45,* 708-719.

Falkner, N. H., Neumark-Sztainer, D., Story, M., Jeffery, R. W., Beuhring, T., & Resnick, M. D. (2001). Social, educational, and psychological correlates of weight status in adolescents. *Obesity Research, 9*(1), 32-42.

Gast, A., & Rothermund, K. (2011). What you see is what will change: Evaluative conditioning effects depend on a focus of valence. *Cognition & Emotion, 25*(1), 89-110.

Greenwald, A. G., & Farham, S. D. (2000). Using the implicit association test to measure self-esteem and self-concept. *Journal of Personality and Social Psychology, 79*(6), 1022-1038.

Greenwald, A. G., McGhee, D. E., Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology, 74*(6), 1464-1480.

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85*(2), 197-216.

Harris, J. L., Bargh, J. A., & Brownell, K. D. (2009). Priming effects of television food advertising on eating behavior. *Health Psychology, 28*(4), 404-413.

Hattar, A., Hagger, M. S., & Pal, S. (2015). Weight-loss intervention using implementation intentions and mental imagery: A randomised control trial study protocol. *BMC Public Health, 15*, 196-208.

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs, 76*(4), 408-420.

Hayes, A. F. (2013). *An introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York, NY: Guilford Press.

Haynes, A., Kemps, E., & Moffitt, R. (2015). Inhibitory self-control moderates the effect of changed implicit food evaluations on snack food consumption. *Appetite, 90,* 114-122.

Hoefling, A., & Strack, F. (2008). The tempting effect of forbidden foods. High calorie content evokes conflicting implicit and explicit evaluations in restrained eaters. *Appetite, 51*, 681-689.

Hofmann, W., Friese, M., & Wiers, R. W. (2009). Impulsive versus reflective influences on health behavior: A theoretical framework and empirical review. *Health Psychology Review, 2*(2), 111-137.

Hofmann, W., Perugini, M., de Houwer, J., & Baeyens, F. (2010). Evaluative conditioning in humans: A meta-analysis. *Psychological Bulletin, 136*(3), 390-421.

Hollands, G. J., Marteau, T. M., & Prestwich, A. (2011). Using aversive images to enhance healthy food choices and implicit attitudes: An experimental test of evaluative conditioning. *Health Psychology, 30*(2), 195-203.

Houben, K., Roefs, A., & Jansen, A. (2012). Guilty pleasures II: Restrained eaters' implicit preferences for high, moderate and low-caloric food. *Eating Behaviors, 13,* 275-277.

Hütter, M., Kutzner, F., & Fiedler, K. (2014). What is learned from repeated pairings? On the scope and generalizability of evaluative conditioning. *Journal of Experimental Psychology: General, 143*(2), 631-643.

IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Jackson, S. E., Beeken, R. J., & Wardle, J. (2015). Obesity, perceived weight discrimination, and psychological well-being in older adults in England. *Obesity, 23*(5), 1105-1111.

Johnson, F., Pratt, M., & Wardle, J. (2012). Dietary restraint and self-regulation in eating behavior. *International Journal of Obesity, 36*, 665-674. doi: 10.1038/ijo.2011.156

Jones, C. R., Fazio, R. H., & Olson, M. A. (2009). Implicit misattribution as a mechanism underlying evaluative conditioning. *Journal of Personality and Social Psychology, 96*(5), 933-948.

Kattner, F. (2012). Revisiting the relation between contingency awareness and attention: Evaluative conditioning relies on a contingency focus. *Cognition & Emotion, 26*(1), 166-175.

Kim, H. I., & Johnson, S. P. (2013). Do young infants prefer an infant-directed face or a happy face? *International Journal of Behavioral Development, 37*(2), 125-130.

Lascelles, K. R. R., Field, A. P., & Davey, G. C. L. (2003). Using foods as SCs and body shapes as UCSs: A putative role for associative learning in the development of eating disorders. *Behaviour Therapy, 34*, 213-235.

Lebens, H., Roefs, A., Martijn, C., Houben, K., Nederkoorn, C., & Jansen, A. (2011). Making implicit measures of associations with snack foods more negative through evaluative conditioning. *Eating Behaviors, 12*, 249-253.

Levey, A. B., & Martin, I. (1975). Classical conditioning of human 'evaluative' responses. *Behavioural Research & Therapy, 13*, 221-226.

MathWorks. (2014). MATLAB R2014a, v. 8.3. Natick, MA: The MathWorks Inc.

Mercer, M. E., & Holder, M. D. (1997). Food cravings, endogenous opioid peptides, and food intake: A review. *Appetite, 29,* 325-352.

Moffitt, R., & Brinkworth, G., Noakes, M., & Mohr, P. (2012). A comparison of cognitive restructuring and cognitive defusion as strategies for resisting a craved food. *Psychology & Health, 27*, 74-90.

Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F. … Marks, J. S. (2003). Prevalence of obesity, diabetes and obesity-related health risk factors, 2001. *Journal of the American Medical Association, 289*(1), 76-79.

Must, A., Spadano, J., Coakley, E. H., Field, A. E., Colditz, G., & Dietz, W. H. (1999). The disease burden associated with overweight and obesity. *Journal of the American Medical Association, 282*(16), 1523-1529.

Naughton, P., McCarthy, M., & McCarthy, S. (2015). Acting to self-regulate unhealthy eating habits. An investigation into the effects of habit, hedonic hunger and self-regulation on sugar consumption from confectionery foods. *Food Quality and Preference, 46,* 173-183. doi: 10.1016/j.foodqual.2015.08.001

Nosek, B. A., Greenwald, A. G., & Banaji, M. R. (2005). Understanding and using the Implicit Association Test: II. Method variables and construct validity. *Personality and Social Psychology Bulletin, 31*(2), 166-180.

Stice, E. (1998). Modeling of eating pathology and social reinforcement of the thin-ideal predict onset of bulimic symptoms. *Behaviour Research & Therapy, 36*, 931-944.

Subar, A. F., Thompson, F. E., Kipnis, V., Midthune, D., McNutt, S., …, Rosenfeld, S. (2001). Comparative validation of the Block, Willett, and National Cancer Institute food frequency questionnaire: The Eating at America's Table study. *American Journal of Epidemiology, 154,* 1089-1099.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., … Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168*(3), 242-249.

van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behaviour. *International Journal of Eating Disorders, 5*(2), 295-315.

Walsh, E. M., & Kiviniemi, M. T. (2014). Changing how I feel about food: Experimentally manipulated affective associations with fruits change fruit choice behaviors. *Journal of Behavioural Medicine, 37,* 322-331.

Walther, E. (2002). Guilty by mere association: Evaluative conditioning and the spreading attitude effect. *Journal of Personality and Social Psychology, 82,* 919-934.

Wansink, B., Painter, J. E., & North, K. (2005). Bottomless bowls: why visual cues of portion size may influence intake. *Obesity Research, 13,* 93-100.

Wiers, R. W., Rinck, M., Kordts, R., Houben, K., & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction, 105,* 279-287.

Table 1. Descriptive statistics of the sample by Evaluative Conditioning (EC) condition. Data are Mean (SD) or N (%). Difference test is t-test for all except gender, education level, and ethnicity, for which a chi-square test was performed.

Variables	All	EC condition		Difference statistic and *p*-value
	N = 95	Healthy-happy/ unhealthy-angry N = 47	Unhealthy-happy/ healthy-angry N = 48	
Gender[a]	70 (73.68%)	36 (76.60%)	34 (70.83%)	χ^2=0.41, p=.52
Age	24.88 (6.16)	24.15 (5.85)	25.60 (6.43)	t=1.15, p=.25
Body Mass Index (BMI)	21.31 (3.13)	20.86 (2.78)	21.85 (3.47)	t=1.46, p=.15
Education level				
High school	8 (8.42%)	6 (12.77%)	2 (4.17%)	χ^2=5.43, p=.25
Higher education	10 (10.53%)	6 (12.77%)	4 (8.33%)	
Bachelor's degree	48 (50.53%)	25 (53.19%)	23 (47.92%)	
Master's degree	25 (26.32%)	9 (19.15%)	16 (33.33%)	
Doctorate	4 (4.21%)	1 (2.13%)	3 (6.25%)	
Ethnicity				
White Caucasian	41 (43.16%)	19 (40.43%)	22 (45.83%)	χ^2=3.63, p=.31
Asian or Asian British	48 (50.53%)	23 (48.94%)	25 (52.08%)	
Black or Black British	3 (3.16%)	3 (6.38%)	0 (0.00%)	
Other	3 (3.16%)	2 (4.26%)	1 (2.08%)	
Restrained eating	2.32 (0.75)	2.49 (0.71)	2.16 (0.76)	t=2.14, p=.04*
Emotional eating	2.53 (0.84)	2.66 (0.77)	2.41 (0.90)	t=1.49, p=.14
External eating	3.24 (0.50)	3.23 (0.50)	3.25 (0.52)	t=0.26, p=.80
NCI Quick Food Scan	3.51 (2.38)	3.68 (2.64)	3.34 (2.10)	t=0.71, p=.48
IAT history[b]	26 (27.37%)	14 (29.79%)	12 (25.00%)	t=0.52, p=.61
Hours since last meal	6.15 (3.92)	6.30 (4.12)	5.99 (3.76)	t=0.39, p=.70

[a] Number of females in the sample
[b] Number of people who knew what an IAT was or had participated in an IAT before
* Significant at *p*<.05

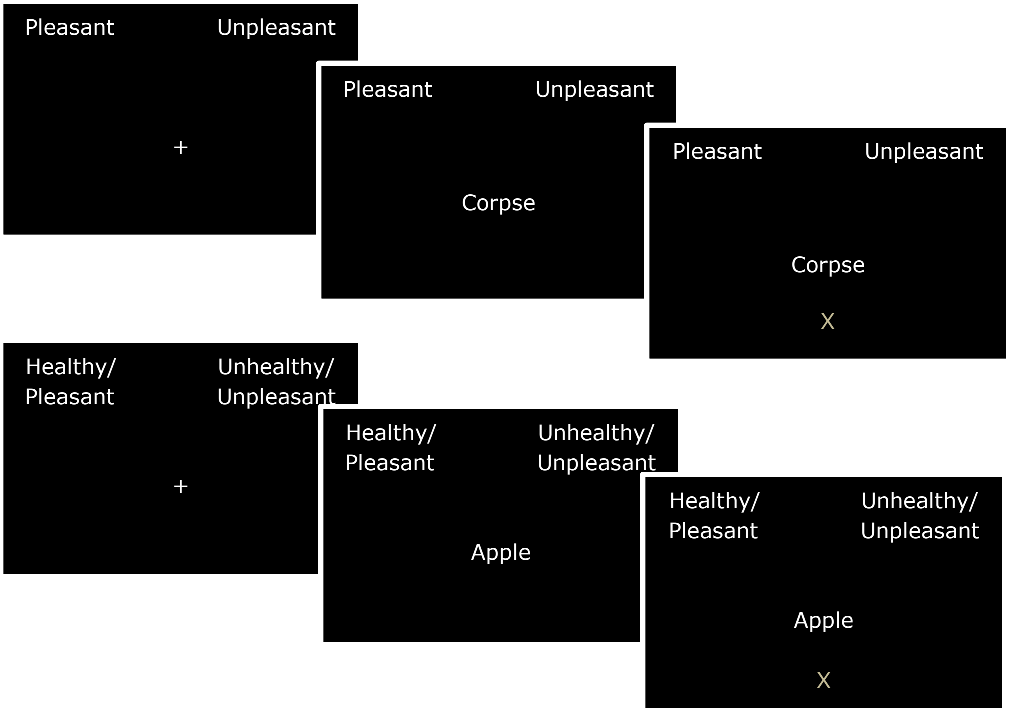

Figure 1a. The top three squares represent a task schematic of a typical trial during the practice blocks of the implicit association task (IAT). One category appears in the upper left corner, and one in the upper right corner. A fixation cross appears for 1000ms, after which a word is presented which needs to be sorted into one of the two categories. If the participant sorts the word correctly, they move on to the next trial. If the answer is incorrect, a red cross appears below the word which does not disappear until the participant has corrected their answer, after which the next trial is presented. This means that the task had a built-in time penalty for incorrect answers. **1b.** The bottom three squares represent a task schematic of a typical trial during the data collection blocks of the IAT. Two categories appear in the upper left corner, and two in the upper right corner. A fixation cross appears for 1000ms, after which a word is presented which needs to be sorted into one of the four categories, so to one of the two sides. The same time penalty for incorrect answers applies.

Figure 2. This picture represents a typical trial of the decision-making task, during which participants had to make choices between healthy and unhealthy foods. Participants pressed ‘z’ if they wanted the left item, and ‘m’ if they wanted the right item.

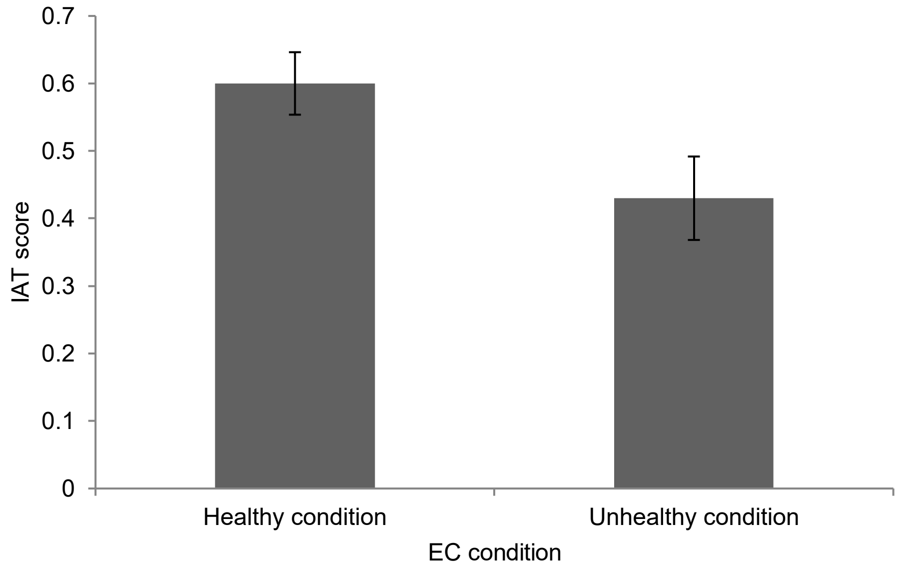

Figure 3. Bar graph showing IAT score (indicating implicit food preference) as a function of EC condition. A positive score indicates a general preference for healthy food. The higher the absolute number, the stronger the preference. The difference between conditions is significant (B=0.17, *t*(92)=2.16, p=.033).

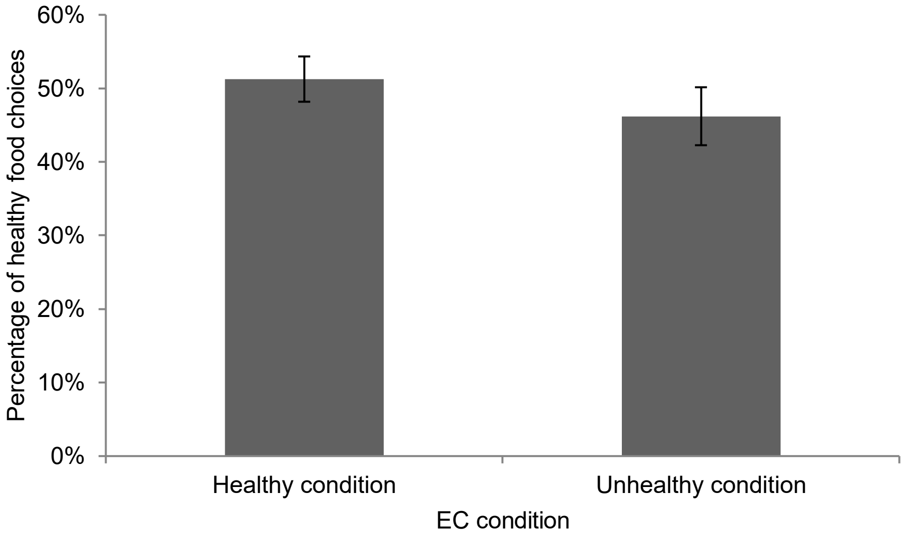

Figure 4. Bar graph showing percentage of healthy food choices made during the food decision-making task as a function of EC condition. The difference between conditions is not significant (B=0.04, $t(92)=0.70$, p=.49).

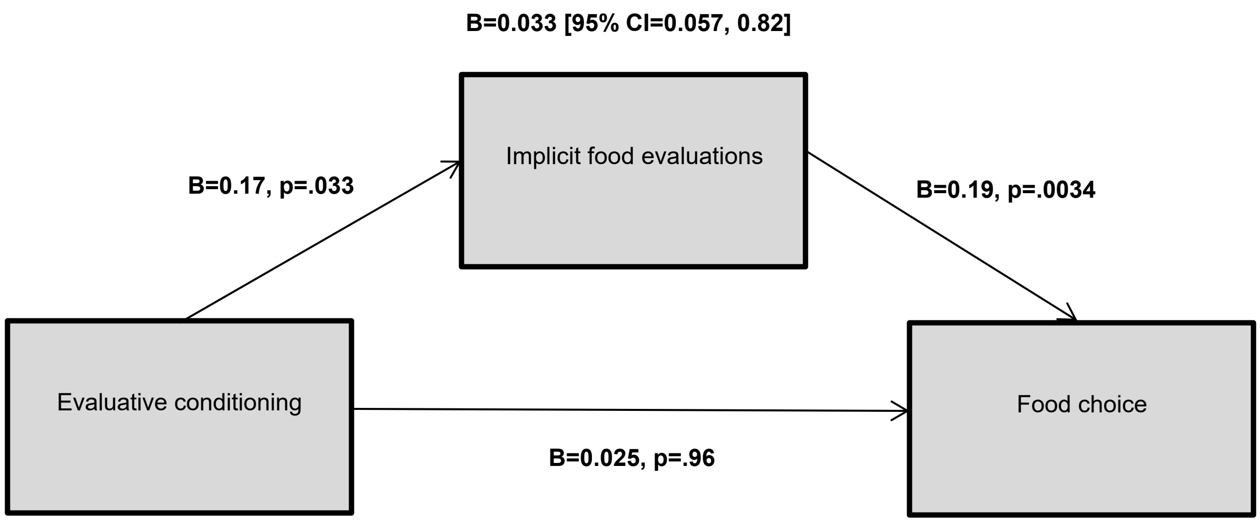

Figure 5. A mediation model showing the indirect effect of evaluative conditioning leading to a change in food choice through a change in implicit food evaluations.

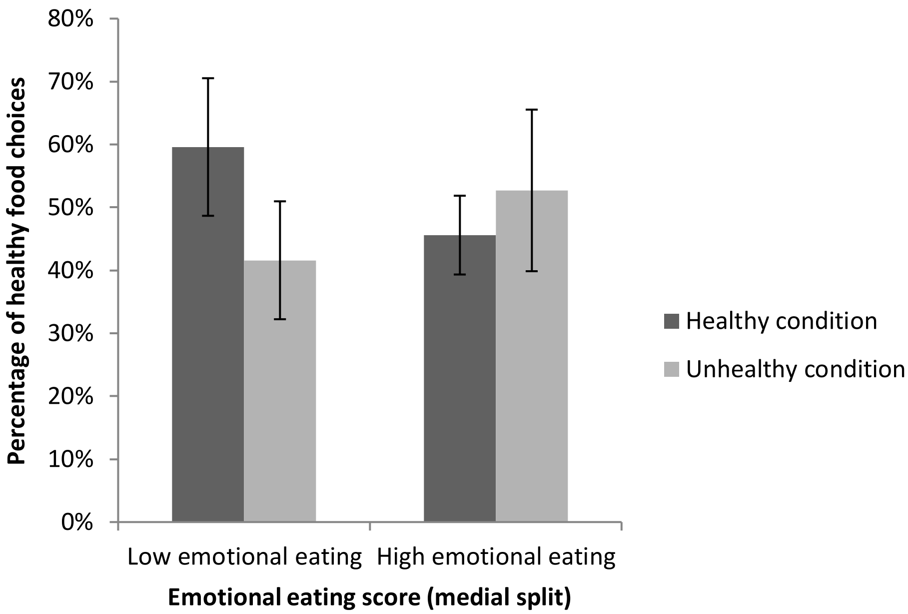

Figure 6. Significant interaction effect between EC condition emotional eating on food choice (F(1, 90)=6.37, p=.013).