Health Psychology
2011, Vol. 30, No. 2, 195–203

0278-6133/11/$12.00 DOI: 10.1037/a0022261

Using Aversive Images to Enhance Healthy Food Choices and Implicit Attitudes: An Experimental Test of Evaluative Conditioning

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Objective: To examine the effect of communicating images of energy-dense snack foods paired with aversive images of the potential health consequences of unhealthy eating, on implicit and explicit attitudes and food choice behavior. ***Design:*** Participants were randomly allocated to either an evaluative conditioning (EC) procedure that paired images of snack foods with images of potential adverse health consequences or a control condition that featured images of snack foods alone. ***Main Outcome Measures:*** Implicit attitudes were assessed pre- and post-intervention. Explicit attitudes and food choice behavior were assessed post-intervention. ***Results:*** The conditioning intervention made implicit attitudes toward energy-dense snacks more negative, with this effect greatest in those with relatively more favorable implicit attitudes toward these snacks at baseline. Participants in the conditioning intervention were more likely to choose fruit rather than snacks in a behavioral choice task, a relationship mediated by changes in implicit attitudes. ***Conclusion:*** Presenting aversive images of potential health consequences with those of specific foodstuffs can change implicit attitudes, which impacts on subsequent food choice behavior.

Keywords: health risk, conditioning, implicit attitudes, explicit attitudes, behavior

There is growing evidence to suggest that communicating information about health risks using vivid, aversive images of the potential adverse health consequences of a given behavior, could be a means to motivate behavior to reduce such risks. This has been examined in relation to both the personalized communication of pathological images of the individual, as derived from a range of medical imaging techniques assessing current health status (for review see Hollands, Hankins, & Marteau, 2010), and at the population level (see Hollands, Cameron, Crockett, & Marteau, in press). Supportive evidence has been presented for the use of graphic picture warnings within population-level interventions, such as anti-smoking communications on cigarette packaging (e.g., Hammond, Fong, McDonald, Cameron, & Brown, 2007). However, evidence of both the behavioral effects of these warnings and the cognitive and emotional processes underlying these, is limited through the use of non-experimental designs and a focus on a narrow range of behavior, mainly smoking. These limitations raise questions regarding the veracity of broad claims of effectiveness (Ruiter & Kok, 2005). The current study presents a novel test of the effect of communicating aversive images, associating images of potential adverse health consequences with those of energy-dense snack foods images, on food choice behavior and the mechanisms underlying this relationship.

Evaluative conditioning (EC) is a process that involves repeatedly pairing an attitude object (conditioned stimulus, CS) with positively or negatively valenced stimuli (unconditioned stimulus, US) in an attempt to respectively create liking or disliking of the attitude object (for reviews, see De Houwer, Thomas, & Baeyens, 2001; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010; Walther & Langer, 2008). The pairing of products (e.g., cigarette packaging) with particular types of emotionally valenced stimuli (e.g., images related to adverse health consequences) reflects this process. Although there is a significant body of EC literature within the field of consumer science, this has rarely been applied to health behavior. However, as some health-related behaviors, such as food choice, are conceptually similar to choices made between branded products, the wider literature is informative. There have been consistent findings that the presentation of visual stimuli in this way can alter attitudes and behavioral intentions (in this case, purchase intentions) toward a range of branded products (e.g., Kim, Lim, & Bhargava, 1998; Shimp, Stuart, & Engle, 1991). Gibson (2008) demonstrated that allocation to either a Coca-Cola® or Pepsi-Cola positive conditioning group predicted choice between the products in line with the allocation, although only when participants were under high cognitive load.

Recent literature in social psychology has sought to explain the effects that emerge through EC procedures, with a clear distinction drawn between implicit and explicit attitudes (Greenwald et al., 2002). Explicit attitudes are those that are traditionally measured by asking participants to express, through self-report, the per-

Accepted under the editorial term of Robert M. Kaplan.

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ceived pleasantness of a given stimulus, and are more deliberative and propositional in nature (Gawronski & Bodenhausen, 2006). Implicit attitudes, by contrast, are more automatic, impulsive, and are primarily based on associations in memory, and are assessed through indirect methods such as reaction-time based tasks.

The relationship between explicit and implicit attitudes is uncertain and the strength of their relationship varies significantly (Nosek, 2005). However, they can be shifted independently of one another (Gregg, Seibt, & Banaji, 2006) and have been shown to be differentially susceptible to change through EC, with implicit attitudes tending to reflect evoked changes in associative structures, even for well-rehearsed attitudes (Olson & Fazio, 2006). As such, it is suggested that implicit attitudes should be measured when evaluating the impact of an EC procedure (Mitchell, Anderson, & Lovibond, 2003). Gawronski and Bodenhausen (2006) reviewed a number of studies that illustrate that such attitudes are amenable to change and the instances in which changes can occur at the implicit but not explicit level (cf. Case 2 of Gawronski & Bodenhausen, 2006, pp. 704–705). They argued that changes in implicit attitudes can occur without change in explicit attitudes, especially when the association between the CS (e.g., energy dense snack foods) and US (e.g., aversive images of health consequences) is salient and thus the individual is particularly aware of the CS–US contingency. As such, making very clear the association between images and particular foods through an EC procedure should influence implicit, but not explicit, attitudes. However, although there is a growing body of evidence that implicit attitudes are malleable by EC, this has principally been shown in other social-psychological domains (e.g., Baccus, Baldwin, & Packer, 2004; Gibson, 2008; Prestwich, Perugini, Hurling, & Richetin, 2010; Rydell, McConnell, Mackie, & Strain, 2006), with few studies to this point examining this in relation to health or food-related attitudes.

Whether implicit attitude change has consequences for food behaviors is also dependent on implicit attitudes predicting these types of behaviors; a finding for which there is accumulating evidence. In a meta-analysis, Greenwald, Poehlman, Uhlmann, and Banaji (2009) found that across all studies of the implicit attitude–behavior relationship, the overall effect size was $r = .27$. This rose to $r = .32$ when the focus was on studies of consumer preferences. In the domain of health-related food behaviors, implicit attitudes have been shown to correlate with self-reported snack consumption (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007; Friese, Hofmann, & Wänke, 2008, Study 2; Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008, Study 2) and self-reported low-calorie food intake habits (Maison, Greenwald, & Bruin, 2001). There has been some more objective evidence, that has not relied on self-reports, demonstrating that implicit attitudes predict participants' choices when presented with a range of foods from which they could select. These have typically been presented as a reward for participation in the experiment (Conner et al., 2007; Friese et al., 2008, Study 1; Perugini, 2005, Study 2). However, implicit attitudes have also been shown to predict healthy–unhealthy food purchases of participants presented with the option of buying fruit, chocolate, or making no purchase (Prestwich, Hurling & Baker, in press).

Considering that EC can change implicit attitudes and change behavior and that implicit attitudes correspond with food-related behaviors, it follows that implicit attitudes could mediate behavior change, resulting from EC. Unfortunately, few studies have examined the mediating role of implicit attitudes, and these have tended to focus on their impact on explicit cognitions, usually explicit attitudes (e.g., Whitfield & Jordan, 2009), but also behavioral intention (Dasgupta & Rivera, 2008). To our knowledge, only one published work has tested, and demonstrated, that changes in implicit attitudes mediate behavior change (Strick, van Baaren, Holland, & van Knippenberg, 2009). Strick et al. used a very different conditioning paradigm (the use of humorous and non-humorous cartoons in a mock magazine) to that used in our research, concerned non-health-related product preference (scissors vs. pens; preference for different brands of energy drink), and used association with positive (humorous cartoons) valenced stimuli rather than clearly negative valenced stimuli. Moreover, these studies have been conducted outside of the realm of health psychology. As such, our research presented a novel test in a new domain.

Given the potential role of implicit attitudes in mediating the effects of a conditioning procedure, underlying theoretical frameworks should be considered. Models of behavior typically applied in health psychology tend not to account for the role of implicit attitudes and other forms of impulsive processing. From social and cognitive psychology, dual-systems models such as the reflective impulsive model (RIM; Strack & Deutsch, 2004) and the associative-propositional evaluation model (APE; Gawronski & Bodenhausen, 2006) attempt to explain the relative role of reflective and impulsive processes in guiding behavior and therefore can provide an overarching framework for the key hypotheses in the current study. As such, these approaches can be used to understand the suggested effects of both EC on implicit attitudes and of implicit attitudes on behavior.

Strack and Deutsch (2004) described impulsive and reflective processing that can jointly influence behavior through the co-activation of behavioral schema. For example, following perceptual input (e.g., smelling or seeing chocolate), a process of spreading activation occurs whereby the activation of particular concepts (e.g., chocolate) leads to the quick-fire activation of associated concepts (e.g., love, tasty) within an impulsive system. These can be re-activated associations that have been learned in the past or newly formed associations developed through contingency learning, such as EC (Gawronski & Bodenhausen, 2006). In addition, an individual can see an object (a chocolate bar), classify it as a chocolate bar, draw on factual (e.g., unhealthy) and evaluative (e.g., I like chocolate bars) information, and derive at the formulation of an intention (e.g., with regard to approach, buy, eat; or avoid, not buy, not eat the chocolate). These reflective processes can jointly activate the behavioral schema alongside input from the impulsive system. However, recent reviews (Friese, Hofmann, & Schmitt, 2008; Hofmann, Friese, & Wiers, 2008) suggest that in circumstances where there is little motivation or opportunity to process information, or limited self-regulatory resources (see Hofmann, Rauch, & Gawronski, 2007), impulsive processing and thus implicit attitudes are argued to be key, and perhaps dominant, determinants of behavior, relative to contexts that emphasize reflective processes. These predispose the organism to approach or avoid relevant stimuli in the environment (Hofmann et al., 2008) and, thus, can directly influence behavior such as food choices. As applied to this experiment, implicit attitudes (that have been purported to tap into an impulsive system) would be anticipated to

significantly predict behavior, given that participants are asked to make relatively spontaneous behavioral choices of low-value rewards.

Summary and Hypotheses

Although research has demonstrated the potential utility of aversive health-related images and text in changing smoking cognitions and behaviors (Germain, Wakefield, & Durkin, 2010; White, Webster, & Wakefield, 2008), their impact on other health behaviors is unknown. In this contribution, we assessed the impact of an EC procedure, pairing images of energy-dense snack foods with images of potential health consequences, such as of cardiovascular disease and obesity, on food choice behavior, and examined the mechanisms underlying this effect.

Implicit attitudes, rather than explicit attitudes, have been shown to be amenable to change through EC when there is a particularly clear, observable link between the CS and US (Gawronski & Bodenhausen, 2006). Furthermore, various studies have shown that implicit attitudes predict food choices, even after controlling for explicit attitudes (e.g., Richetin, Perugini, Prestwich, & O'Gorman, 2007). Consequently, it was predicted that participants who were presented with aversive images of potential health consequences repeatedly paired with images of energy-dense snack foods, compared to those in the control group, would show a relatively weaker preference for snacks over fruit on a behavioral choice task (Hypothesis 1) and develop a corresponding implicit attitudinal preference (Hypothesis 2a) that mediates the effect of the intervention on food choice (Hypothesis 3). As the conditioning procedure is predicted to make implicit attitudes toward snacks more negative, it follows that individuals who already hold highly negative implicit attitudes toward snacks will be less affected. It was therefore hypothesized that the main effect on implicit attitudes should be greater in those participants with relatively stronger implicit preference for snacks over fruit at baseline (Hypothesis 2b). Finally, although the intervention was not predicted to alter explicit attitudes, it was expected that post-intervention levels of both explicit and implicit attitudes would explain food choice to a significant degree (Hypothesis 4), in line with other research, which suggests such an additive model of these mechanisms' relative effects (Richetin et al., 2007; Greenwald et al., 2009).

Method

Sample

Given power of 0.80 and an alpha level of .05, an effect on the primary outcome of $d = 0.5$ (in line with a recent meta-analysis, Hofmann et al., 2010, which found a mean average effect of EC of $d = 0.52$) would require 128 participants. Therefore, allowing for the possibility of computer errors and missing data, 134 participants (mean age = 24.2 years, 101 female) were recruited, by a circular email to King's College London staff and students.

Randomization

Participants were randomly allocated by a computer program (E-Prime; Schneider, Eschman, & Zuccolotto, 2002) to either a control or intervention group that dictated which set of images were viewed. As the participants were randomly allocated to condition while alone in a testing room, the study personnel were not aware of this allocation.

Manipulation (Intervention)

Participants were asked to watch a slideshow that featured 100 images (five snack images shown 20 times in a random order). Each of the 100 trials lasted 2.5 s in total, with the snack image appearing for one second, followed by the presentation of a either a blank screen (control condition) or the presentation of one of five aversive bodily images (intervention condition) for one second. To ensure that participants concentrated fully on the images, they were instructed to respond to the brief random appearance of a white circle at five intertrial points throughout the slideshow, by pressing a given key. The intertrial interval was 500 ms.

The images used in the study were first piloted on a group of volunteers ($n = 12$). In regard to the snack images, participants were shown three different images for a range of foodstuffs and asked to pick those images that were most clear and representative of each. The five snack images selected portrayed chocolate, biscuits, cake, crisps, and a range of snacks. From a pool of 30 health-related images, which portrayed potential consequences of an unhealthy diet, such as heart disease and obesity, and deemed to be broadly equivalent in content to those used in cigarette packaging, participants rated each on a rating scale of one (*unpleasant*) to 10 (*pleasant*). Cumulative scores were collated, and the images considered most unpleasant were chosen. The pilot participants were also consulted on the addition of text to those images that were not obvious in their content, and the words "artery disease" were added to two of the five images as a result.

The five aversive images selected consisted of two images of obesity (in men and women), two images of arterial disease and one of heart surgery (see Figure 1 for examples).

Measurement of Outcomes

All measures were completed individually in a separate room. Pre- and post-intervention measures and the intervention were all completed in one session. Implicit attitudes were assessed pre- and post-intervention with all other measures taken post-intervention only. After providing their informed consent, the measures were completed in the following order: (a) baseline measure of implicit attitudes; (b) a distraction word-search task, comprising animal names and lasting for 5 min; (c) intervention procedure; (d) post-intervention measure of implicit attitudes; (e) explicit attitude measure; and finally, (f) the food choice task, before the debrief.

Primary Outcome Measure. As an index of behavior, participants were asked to make two choices between fruit and snack products, both presented as rewards for their participation. For the first, they were presented with a bowl that contained both fruit (apple, orange, banana, grapes) and snacks (cake bar, chocolate bar, crisps, biscuits) items and asked to choose one item to take home with them. These items corresponded to exemplars in the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) task and were matched as closely as possible for size and value. For the second, they were offered a choice of a £3 ($4.50) voucher to spend either at a fruit or a confectionery stand at the nearby train station. For both choices, participants could respond

Figure 1. Example conditioning procedure images (images self-produced–public domain, Wikimedia Foundation, 2010).

by choosing a fruit, a snack, or neither, which was taken as consistent with no preference either way. Responses were summed on a corresponding 5-point scale of overall behavioral preference for fruit or snacks. This was scored from −2 (*two choices of snacks made in the task*) to +2, (*two choices of fruit made in the task*), centered on 0, which indicated no observed behavioral preference in either direction. Similar fixed-choice measures have been used in implicit attitude research (e.g., Conner et al., 2007; Friese at al., 2008, Study 1; Perugini, 2005, Study 2).

Secondary Outcome Measures. Implicit attitudes were assessed using the IAT (Greenwald et al., 1998). The critical tasks of the IAT require participants to sort words that relate to one of four categories to one of two response keys. The assumption is that responses to categories that are highly associated in memory are assumed to be faster when they share the same response key, relative to the response to categories not associated in memory. The four categories comprised two targets (*fruits*, with the exemplars fruits, apple, banana, grapes, orange; and *snacks*, with the exemplars, chocolate, biscuits, cake, snacks, crisps) and two attributes (*pleasant*, with the exemplars, rainbow, happy, smile, joy, peace; and *unpleasant*, with the exemplars, pain, death, poison, agony, sickness). In the critical tasks, stimuli from all four categories were presented in a random order, and participants assigned them to one of two combined category-attribute pairs (e.g., left computer key for fruits–pleasant and right key for snacks–unpleasant). A second combined task switched the targets (e.g., left computer key for snacks–pleasant and right key for fruits–unpleasant). The category headings were displayed throughout in the left- and right-hand corners of the screen. Errors in sorting were pointed out, with an accurate response being necessary to move on to the next presentation. Participants were required to respond by pressing the *E* or *I* keys. The order of the block assignment within the IAT was counterbalanced, although no order effects were observed.

An IAT score is computed as a function of the difference of the mean response time between the two versions of the critical combined task. Specifically in this study, the IAT score was calculated by using the scoring procedures recommended in a revised algorithm by Greenwald, Nosek, and Banaji (2003), with a more positive score indicating a more positive attitude to fruit (and more negative attitude to snacks). The IAT typically displays good internal consistency, and relative insensitivity to variations in both subject familiarity with the stimuli used in the task (Ottaway, Hayden, & Oakes, 2001) and in procedural changes, such as the number of trials (Nosek, Greenwald, & Banaji, 2005). In a review of the literature, Nosek, Greenwald, & Banaji (2007) reported an adequate median test–retest reliability of $r = .56$ across nine available reports.

Explicit attitudes toward fruits and snacks were assessed separately ("For me, eating fruit/snacks is") along five 7-point semantic differential scales (*not at all healthy–healthy; bad–not at all bad; not at all enjoyable–enjoyable; not at all unpleasant–unpleasant; good–not at all good*) and reverse scored where appropriate. Composite scales ($\alpha = .70$ and .69, respectively) were produced, and in line with previous research that uses a fruit–snack comparison (Perugini, 2005), summed explicit attitude scores for snacks were subtracted from those for fruits to give an overall explicit attitude score, with positive scores indicating relative preference for fruit.

In addition to the key attitude measures, single-item measures were included in the post-intervention questionnaire to explore a wider range of responses to the intervention, and assessed worry about diet, worry about health consequences, coherence between representations and recommended behavior, self-efficacy and response-efficacy. There were no main effects of the intervention on any of these measures, and they are referred to briefly only in the Discussion section.

Data Analysis

We used *t* tests and chi-square analysis to examine baseline differences between the two conditions. Analysis of covariance (ANCOVA) and moderated regression tested the main effect of the intervention on implicit attitude change and whether the effect was greater for those with relatively more favorable implicit attitudes toward snacks at baseline. Post-intervention differences in explicit attitudes were assessed with ANCOVA, as were differences in food choice. Analysis of mediation effects used path analysis and bootstrapping techniques. Standard forced-entry multiple linear regressions analysis was used to test the unique contributions of implicit and explicit attitudes in predicting food choice. Participants with markedly outlying results on post-test IAT scores that controlled for baseline, as identified by the SPSS outlier function ($n = 2$) were removed from subsequent analysis (see the footnotes and Discussion section).

Results

There were no withdrawals and to our knowledge, all participants adhered to the trial protocol. Two-tailed p values are reported throughout.

Baseline Characteristics of the Sample

The baseline characteristics of the participants are summarized in Table 1. Across the two conditions, there were no significant differences in gender ($p = .153$) or baseline IAT scores ($p = .505$), although the mean age of the control group was higher, $t(130) = 2.44$, $p = .016$. Subsequent analysis controlled for demographic variables (age and gender).

Intervention Effects on Primary Outcome

In the behavioral food choice task, participants in the intervention condition chose fruit (as opposed to snacks) more often than those in the control condition (respective means of 1.33 vs. 0.17 on the food choice index, indicating the number of choices of fruit made, see Table 2). This effect was significant, $F(1, 128) = 25.20$, $p < .001$, $r = .40$, supporting Hypothesis 1.[1]

Intervention Effects on Secondary Outcomes

In relation to Hypothesis 2a, after controlling for baseline IAT scores (plus age and gender), intervention condition marginally predicted post-intervention IAT scores for the complete sample, $F(1, 127) = 3.62$, $p = .06$, $r = .17$ (although this effect was statistically significant, $p = .033$, if we did not control for age and gender). Higher mean IAT scores were observed in the intervention group, indicating a relatively stronger implicit preference for fruit over snacks compared with the control group. As predicted by Hypothesis 2b, there was a significant interaction between baseline IAT scores and condition, $\beta = -.28$, $t(\cdot) = -2.31$, $p = .02$. Simple slopes analysis revealed that the intervention significantly decreased implicit preference for snacks relative to fruit in those individuals that had a stronger, $\beta = .52$, $t(\cdot) = 3.03$, $p = .003$, or moderate, $\beta = .24$, $t(\cdot) = 1.97$, $p = .05$, preference for snacks over fruits at baseline, but not for those with a weaker, $\beta = -.04$, $t(\cdot) = -0.22$, $p = .83$, initial preference for snacks (see Figure 2). There was no effect of the intervention on explicit attitudes, $F(1, 128) = 0.37$, $p = .544$, $r = .05$.

Table 1
Baseline Characteristics Across Conditions

Condition	No. of women (%)	Age		IAT score	
		M	*SD*	*M*	*D*
Intervention ($n = 66$)	54 (80.6)	22.59	5.26	.50	.51
Control ($n = 66$)	47 (70.1)	25.85	9.49	.56	.51
Total	101 (75.3)	24.22	7.82	.53	.51

Note. $N = 132$. IAT = Implicit Association Test.

Table 2
Post-Intervention Primary and Secondary Outcome Means

Condition	IAT score (*D*) (adjusted for baseline)	Explicit attitudes		No.of choices of fruit in behavioral task$_{(\text{scale of } -2 \text{ to } +2)}$
		M	*SD*	
Intervention ($n = 66$)	.66 (.32)	11.94	4.79	1.33 (1.09)
Control ($n = 66$)	.54 (.32)	11.30	5.49	0.17 (1.62)
Total	.60 (.32)	11.62	5.15	0.75 (1.49)

Note. $N = 132$. IAT = Implicit Association Test.

Additional Analysis

As outlined, the intervention was shown to have a significant effect on both implicit attitudes and behavior. A further correlation analysis revealed a significant association between post-intervention implicit attitudes and behavior, $r = .33$, $p < .001$. Mediation analysis, using path analysis and a bias-corrected bootstrap of 10,000 samples, revealed that changes in implicit attitudes (post-intervention IAT score, controlling for baseline IAT, plus age and gender) partially mediated the effect of the intervention on food-choice behavior, indirect effect $\beta = .12$, 95% CI = .00, .25, $p = .044$, supporting Hypothesis 3. A test of moderated mediation (MODMED; Preacher, Rucker, & Hayes, 2007) revealed that baseline implicit attitudes moderated this mediational effect, with mediation being greater in those individuals that had stronger implicit preference for snacks at baseline ($p = .042$). Further evidence of this moderating effect was provided when the mediation model was run, excluding the tertile of participants with weaker baseline preference for snacks (and who did not alter their attitudes as a result of the intervention), with strengthened partial mediation observed, indirect effect $\beta = .25$, 95% CI = .08, .50, $p = .002$.[2] Finally, Hypothesis 4 predicted that post-intervention levels of both implicit and explicit attitudes would both explain unique variance in food choice. This was found to be the case in a regression model with these two variables entered simultaneously, explicit attitudes $\beta = .29$, $t(127 \cdot) = 3.56$, $p = .001$; implicit attitudes $\beta = .27$, $t(127 \cdot) = 3.30$, $p = .001$.

Discussion

In this study, we examined whether individuals' preferences for healthy versus unhealthy foods, as indexed by measures of atti-

[1] The exclusions (of which there was one in each arm, z scores = −4.00 and 2.93) did not significantly alter direct effects on the primary outcome or moderated effects on the secondary outcome (Hypotheses 1 and 2b), with both remaining significant. Their inclusion attenuated the (already nonsignificant) effects of condition on Implicit Association Test (IAT) scores; Hypothesis 2a; $F(1, 129) = 1.25$, $p = .27$.

[2] The indirect non-moderated effect was slightly weaker when the outliers ($n = 2$) remained in the dataset: $\beta = .08$, 95% CI = −.02, .23, $p = .129$, as was the moderated mediation ($p = .118$). However, running the mediation model, excluding the tertile of participants with weaker baseline preference for snacks, did still indicate significant and strengthened partial mediation, indirect effect $\beta = .21$, 95% CI = .05, .46, $p = .007$. The inclusion of outliers did not significantly alter results for Hypothesis 4.

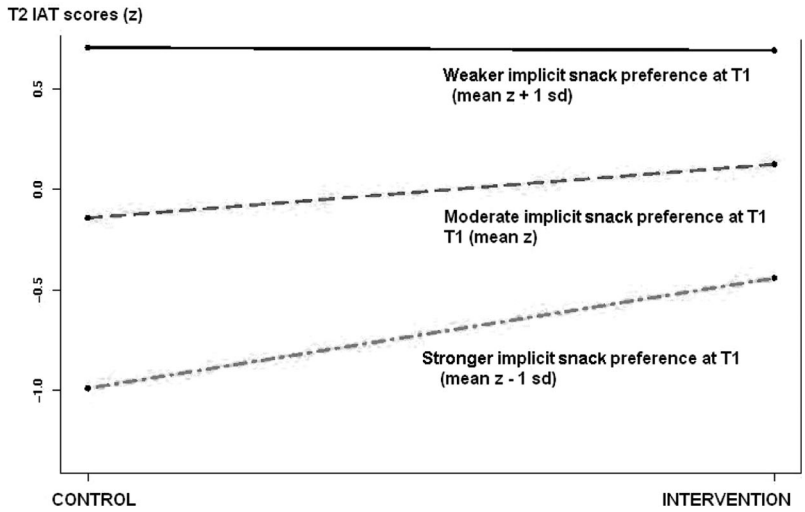

Figure 2. Simple slopes analysis showing the effect of baseline (T1) Implicit Association Test (IAT) score on the intervention effect.

tudes and food choice behavior, can be influenced through an EC procedure, and whether changes in behavior were mediated by changes in implicit attitudes. The EC procedure exposed participants to images of unhealthy snack foods followed by images of potential adverse consequences of an unhealthy diet, such as heart disease and obesity. In support of Hypothesis 1, the EC procedure had significant effects on food-choice behavior, with those in the intervention condition being markedly less likely to choose energy-dense snacks as opposed to fruits. This is of note, because previously there was limited evidence of the impact of EC on behavioral outcomes in this context. Contrary to Hypothesis 2a, (although significance was borderline), the EC-based intervention did not change implicit attitudes for the complete sample. However, there was a significant interaction effect (supporting Hypothesis 2b), with participants in the intervention group who had more favorable baseline implicit attitudes toward unhealthy foods, developing less favorable attitudes toward these foods. The effect of the intervention on food choice was partially mediated by changes in implicit attitudes (partly supporting Hypothesis 3). The findings were also in line with an additive attitudinal model of behavior (see Perugini, 2005) where explicit attitudes and implicit attitudes explain significant unique variance in behavior (supporting Hypothesis 4).

This is, to our knowledge, the first study to demonstrate changes in food-related implicit attitudes, using an EC procedure, and furthermore, that such changes have consequences for health behavior (through the demonstration of a mediational pattern). Across the whole implicit attitude literature, there has been a dearth of studies testing whether changes in implicit attitudes mediate the effects of EC-type interventions on behavior. In fact, we are presently aware of only one such study (Strick et al, 2009). Demonstrating this mediational pattern, within an experimental paradigm, suggests that changes in implicit attitudes represent a mechanism through which such an intervention changes behavior. The identification of such underlying mechanisms is a key feature of theory-based interventions (see Michie & Prestwich, 2010) as they can suggest reasons why interventions were effective, or ineffective, in changing behavior. However, it should be carefully noted that the size of the mediated effects was reduced with the inclusion of two outliers, and we present results analyzed in both ways (see the footnotes). We suggest that such treatment is appropriate given that an aim of the research is to attempt to understand patterns of data that relate to potential underlying mechanisms within a novel paradigm. As such, this result should be treated with caution. Furthermore, although outliers that exert disproportionate influence may indeed be a result of participant or measurement effects, they may also reflect genuine, but seemingly rare, deleterious effects of the intervention, enhancing counter-beneficial preferences for unhealthy foods. This point merits further study.

Consideration of the role of automatic processing in food choice, and across all behaviors, is important, as behavior is not determined solely through non-automatic, reflective processing. Within health psychology, many models suggest that behavioral intentions are a key determinant of behavior. However, a recent review suggests that medium-to-large changes in intentions lead only to small-to-medium changes in behavior (Webb & Sheeran, 2006). Other determinants need to be considered, and more recent models of social behavior (e.g., RIM, Strack, & Deutsch, 2004) highlight the key role of implicit attitudes, a proposition supported by our findings. It is also important to acknowledge that explicit attitudes, although not apparently affected by the intervention (but measured at post-intervention only), also explained unique variance in behavior. As stated previously, this was predicted in line with additive models. True double-dissociation effects, where either implicit or explicit attitudes can be observed to uniquely predict behavior, may be more likely when an experimental manipulation more deliberately targets the inhibition of reflective or impulsive processing (e.g., Hofmann et al. (2007), where participants' self-regulatory resources were depleted).

A recent review of the literature (Hofmann et al., 2010) identified a number of moderators that underlie the effects of EC. These moderators represented features of the EC procedure (e.g., the modality of the US or CS) rather than the potential moderating influence of baseline attitudinal perspectives of the individual. In our study, the

EC-based intervention was shown to have a greater effect on implicit attitudes for those participants who held more positive implicit attitudes toward snacks prior to the intervention. The reduced ability of the intervention to alter implicit attitudes of those who already held negative attitudes toward snacks could be explained by ceiling effects. These may be theoretical, in terms of the intervention's relative inability to alter associative networks already oriented in the desired direction, or pragmatic, when we consider that the task is determined by reaction times, which have a limited range and scope for change. From a health psychology perspective, the identification of this moderator (baseline implicit attitude) is important as it can inform interventions tailored to the needs of the specific individual.

The corroboration of both the malleability of implicit attitudes to an EC procedure, and of the relationship between implicit attitudes and behavior is significant for two reasons. First, although there are problems with measures such as the IAT, as, for example, they may not be as immune to demand or social desirability effects as is often assumed (Gawronski, 2009; Gawronski et al., 2007), they are widely regarded to be less problematic conceptually than explicit questionnaire measures of attitudes. As such, we can have reasonable confidence that observed changes in implicit attitudes reflect a true underlying alteration of (or reactivation of existing) cognitive associations.

Second, although there is mixed evidence as to the stability of implicit attitudes (Devine & Sharp, 2009; Gregg et al., 2006), this study highlights that they can be significantly malleable. There is also evidence that they can determine long-term behavior (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Therefore, it may be that once altered through intervention, implicit attitudes have the ability to influence food choice behavior over the longer term. If they are unstable over time, re-exposure to such associations may reinforce an enduring effect. Longitudinal studies of implicit attitudes and the durability of behavioral effects are warranted, to further explore this assumption.

In terms of methodological strengths, a substantial sample was used in comparison to many previous conditioning studies (see review by Hofmann et al., 2010), and as such, the study was adequately powered *a priori* to find a medium effect size ($d = .50$). According to Hofmann et al.'s meta-analysis, the average effect of EC is $d = .52$. Additionally, substantive effects were found in spite of the intervention's brevity and nonintensive nature, and its single-session design, which was expected to diminish any possible effects. Specifically, repeated exposure to the IAT can lead to practice effects (Olson & Fazio, 2004) that improve performance and reduce the range of results and, thus, the likelihood of detecting significant effects at follow-up.

Limitations of the research should be considered. A key limitation is that our choice of control group is problematic, in terms of inferring that we observed a true EC process. Use of a control group using either neutral images as the US, or the same images as the intervention group but in a randomly presented pattern, may have been more appropriate; allowing us to rule out the possibility that effects were simply because of presentation of the US.

Additionally, we did not use a subtle (e.g., subliminal) EC paradigm. We presented associations in a way broadly analogous to the use of aversive images in interventions (such as product packaging); therefore it being arguably completely appropriate that participants were aware of the US–CS contingencies. However, the use of a subtle approach could be considered more desirable and robust because it reduces the risk of demand effects. Conscious awareness of contingencies has been found to be unnecessary for EC to occur (Olson & Fazio, 2006; Ruys & Stapel, 2009), although meta-analysis by Hofmann et al. (2010) found that contingency awareness was a strong moderator of EC effects, with larger effects when awareness was high rather than low. We suggest that the chosen contingency-aware method was appropriate and valid, as a result of several factors. First, participants were not aware of the nature of their allocation relative to any other group, making it less likely that either group would act in line with the hypotheses. Second, there were no differences in relevant questionnaire measures across groups. If participants were trying to tailor their responses in line with receiving a given image presentation, greater changes on an explicit measure (rather than an implicit measure) would be expected. Third, the resistance to intentional manipulation of implicit measures, relative to explicit measures, is considered one of the strengths of the approach and other studies have justified similar designs on this basis (e.g., Mitchell et al., 2003). Fourth, an informal (albeit unsystematic) discussion with participants at the end of the study suggested there was no conscious manipulation of the results.

Conclusions regarding the effects of the intervention on behavior should be tentative, because of the measure of food choice used in this research. Although similar approaches have been used in other studies (e.g., Karpinski & Hilton, 2001; Perugini, 2005) and an attempt was made to make the tests as ecologically valid as possible (e.g., with the choice of tokens making reference to nearby shops), such fixed choices between fruit and snacks clearly do not adequately reflect the complexities of food-related behavior.

When considering the wider implications of the research, the reported study provides broad support for strategies that seek to change health-related behavior by associating products with aversive images, such as those used on tobacco packaging. However, although it offers preliminary insight into how the use of such images may influence behavior, the findings are clearly not wholly analogous to real-world application and would require numerous iterative stages of research before assuming valid parallels could be drawn. Even if the effectiveness of the use of aversive imagery to alter food choice behavior was comprehensively demonstrated, this may not prove to be an acceptable (to, e.g., consumers, policymakers, or food producers), or feasible, intervention approach, or ultimately be effective in improving population health.

This preliminary study indicates a potentially promising avenue of experimental research on the behavioral impact of aversive image-based communications. Development and assessment of health-communication interventions does not always make use of controlled experimental methods to systematically examine their components and overall efficacy. Doing so will improve insight into the key underlying mechanisms of behavior change, leading to more effective interventions.

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