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Jena A. Shaw [a, *], Evan M. Forman [a], Hallie M. Espel [a], Meghan L. Butryn [a], James D. Herbert [a], Michael R. Lowe [a], Chantal Nederkoorn [b]

[a] Drexel University, 3141 Chestnut St., Department of Psychology, Philadelphia, PA, 19104, United States
[b] Maastricht University, Minderbroedersberg 4-6, 6211 LK, Maastricht, Netherlands

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ABSTRACT

The present study examined the effect of a picture-picture evaluative conditioning (EC) procedure on soft drink (soda) outcomes, including negative implicit attitudes, consumption during a taste test, and real-world consumption reported during the week after the intervention. In the EC condition ($n = 43$), soda images were paired with disgust images and water images were paired with pleasant images, whereas in the control condition ($n = 41$), the same images were viewed without pairing. The EC condition showed a larger reduction in real-world soda consumption across the week following the intervention. However, individuals in the EC condition did not consume less soda during a taste test immediately following the intervention. EC only significantly increased negative implicit attitudes towards soda among individuals who already had relatively higher baseline negative attitudes. These findings generally favored the potential for EC to impact soda drinking habits, but suggest that a brief EC intervention may not be strong enough to change attitudes towards a well-known brand unless negative attitudes are already present.

Calorie-dense foods are easy to like – their sensory properties stimulate the brain's reward centers (e.g., Zhang, Balmadrid, & Kelley, 2003) and their consumption is frequently paired with positive affect both directly through consuming the foods while experiencing positive emotions and indirectly through advertising (e.g., Boyland & Halford, 2013). Not surprisingly, greater liking of calorie-dense foods is associated with consuming these foods more frequently (Raynor, Polley, Wing, & Jeffery, 2004). Dual process models suggest that the liking, or attitude, towards a stimulus (such as a calorie-dense food) and the resulting desire to approach or avoid that stimulus can be evaluated both consciously through explicit processes and unconsciously through implicit processes (Strack & Deutsch, 2004). Explicit processes, which can integrate information about short- and long-term goals to make approach decisions, are often at a disadvantage relative to implicit processes, which automatically prepare an individual to approach or avoid a stimulus based on implicitly-activated attitudes (Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004; Wilson, Lindsey, & Schooler, 2000). If an individual's explicit goals are incompatible with implicitly-activated behavioral impulses, the reflective system must inhibit the activated response, a process often referred to as exerting self-control, in order to achieve successful goal pursuit (Baumeister, Vohs, & Tice, 2007; Wilson et al., 2000).

Implicit attitude measures have been shown to directly predict both self-reported and observed food choices, even when controlling for explicit attitudes (Ayres, Conner, Prestwich, & Smith, 2012; Hollands, Prestwich, & Marteau, 2011). Further, implicit attitudes predict consumption more strongly in individuals with poor or depleted self-control (Friese, Hofmann, & Wanke, 2008; Haynes, Kemps, & Moffitt, 2015; Hofmann, Friese, & Roefs, 2009; Hofmann, Rauch, & Gawronski, 2007), and weight gain over time has been shown to be highest in those with both strong implicit preferences for calorie-dense foods and low self-control (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Because self-control is resource-intensive and becomes weaker with repeated exertion (Baumeister et al., 2007; Muraven & Baumeister, 2000; Friese, Hofmann, & Schmitt, 2008), an individual's attempts to reduce consumption of calorie-dense foods that he or she evaluates positively will tend to fail over time. To facilitate successful dietary change, implicit attitudes themselves might instead be targeted to reduce the automatic tendency to approach these foods.

1. Altering implicit eating attitudes through evaluative conditioning

Evaluative Conditioning (EC) has been used to alter implicit

* Corresponding author. Present address: Perelman School of Medicine at the University of Pennsylvania, 3535 Market St., 3rd Floor, Philadelphia, PA, 19104, United States.
E-mail address: jenashaw@mail.med.upenn.edu (J.A. Shaw).

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attitudes by repeatedly associating a stimulus (conditioned stimulus, CS) with stimuli that have an established affective valence (unconditioned stimulus, US). For example, images featuring a novel product (CS) might be repeatedly presented alongside images of positive stimuli such as smiling faces (US) to increase positive attitudes towards the new product. A recent meta-analysis including 214 studies found that the average effect of EC on implicit attitudes was medium in size ($d = 0.52$, 95% CI: 0.47–0.58), though it was smaller for familiar ($d = 0.20$) than for novel CSs ($d = 0.50$– 0.60; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

Within this literature, studies investigating the impact of EC on eating and other health behaviors are relatively rare (Hollands et al., 2011), and the majority have focused on the acquisition of preferences for novel flavors, foods, and food brands. (e.g., Kerkhof, Vansteenwegen, Baeyens, & Hermans, 2009; Zellner, Rozin, Aron, & Kulish, 1983). Although helping people to acquire positive associations for novel foods might be beneficial to health in some cases, weight loss is most commonly achieved by modifying the frequency or quantities with which familiar foods are consumed. Therefore, in spite of the smaller effect sizes seen with other familiar CS stimuli, investigation of whether attitudes towards familiar foods can be altered by EC is most central to determining whether this procedure represents a viable intervention to support eating behavior change.

A small number of recent studies suggest that EC may be effective for changing implicit attitudes and consumption of familiar foods and beverages. A 2011 study by Hollands, Prestwich, and Marteau used EC to pair images of snack foods with images of aversive health consequences, and found that this procedure reduced implicit snack preferences relative to a no pairing control. In a subsequent reward choice, the EC intervention group was more likely to select fruit instead of snack foods. Two studies found EC to be effective for increasing negative alcohol attitudes in regular drinkers and demonstrated that individuals receiving the intervention consumed less alcohol during a taste test and across the week following the intervention relative to a control condition (Houben, Havermans, & Wiers, 2010; Houben, Schoenmakers, & Wiers, 2010).

However, the conclusions of other studies investigating the effects of EC on consumption have been less definitive. A study investigating the effect of EC on relative preferences for Coke or Pepsi was only able to produce change in implicit attitudes towards the soda brands among individuals whose initial implicit preferences were neutral. A follow-up experiment that recruited individuals with neutral brand attitudes found that EC only predicted reward choice between Coke and Pepsi under cognitive load (Gibson, 2008).

A 2011 study by Lebens et al. used EC to pair snack food and fruit images with negatively and positively valenced body images, respectively. Compared to a random pairing control condition, the EC intervention lowered positive implicit attitudes towards snack foods. However, calories from snack and fruit selections in a subsequent virtual shopping task did not differ by condition. The null effects on this behavioral measure may have been attributable to the appropriateness of the virtual supermarket task to measuring change in the intended items. The availability of a large number of options not related to the conditioning trial, as well as the instruction to purchase enough food for an entire day within a small budget, may have obscured the ability to examine differences in selection of the target foods. Only 10.7% of calories from the foods selected by participants came from either of the targeted food groups (snacks or fruits). However, since few studies have investigated the effect of EC on food choices, it is difficult to determine whether the lack of behavioral effects is attributable to the type of measure used or should be considered a true null finding.

Overall, these findings suggest that EC has the potential to alter attitudes towards familiar foods and beverages. However, because only a small number of studies have been conducted, it is difficult to determine whether the presence of null findings for behavioral outcomes suggests that EC's effect on behavior is unreliable or merely reflects differences in study procedures. Only two studies investigated whether EC can influence behavior beyond the time of the intervention (Houben, Havermans, et al., 2010; Houben, Schoenmakers, et al., 2010), which is essential to determining whether EC might facilitate long-term behavior change. Both studies used retrospective recall methods, so it is not possible to determine whether the intervention influenced reporting accuracy or actual consumption.

In addition, previous studies have examined the short-term effect of EC on the tendency to select the target food/beverage and the frequency with which that food/beverage is reported to be consumed across the follow-up period. No studies have measured whether altering attitudes towards a food or beverage affects the amount consumed when the food/beverage is tasted, which could affect intake above and beyond the tendency to select that food. For example, when consuming a food/beverage that has been paired with negative stimuli, individuals might consume less than if they had not experienced such a pairing. However, it is also possible that existing associations with the food/beverage's taste would override the newly conditioned attitudes. This is therefore an important outcome for investigating the extent of the potential impact of EC on consumption.

2. The current study

The current study sought to replicate findings demonstrating the effect of EC on implicit attitudes and short-term behavior. We also sought to extend previous research by measuring the impact of EC on real-world consumption across a one-week follow-up period using a momentary reporting method that would be less vulnerable to retrospective reporting biases, and by measuring amount consumed during both short- and long-term behavioral measures to be able to more accurately determine the size of EC's impact on dietary intake. Non-diet, sugar-sweetened soft drinks ("soda") were selected as the intervention target because their consumption is associated with increased calorie intake, weight gain and obesity (Couch, 2011; Hu, 2013; Vartanian, Schwartz, & Brownell, 2007). Soda is consumed regularly by approximately half of the U.S. population (Gallup Polling, 2012), which suggests that an intervention that reduces soda consumption could have widespread benefits.

This study compared an EC intervention in which images of soda and water were paired with negative and positive images, respectively, with a control condition in which the same images were presented without pairing. Negative images evoking disgust were selected because previous research suggested that this emotional component increases the effectiveness of EC for appetitive stimuli (Olatunji, Forsyth, & Cherian, 2007; Verwijmeren, Karremans, Stroebe, & Wigboldus, 2012).

We hypothesized that participants in the EC condition would consume less soda than the control during a mock taste-test immediately following the intervention and across the week following the intervention. We also predicted that participants in the EC intervention condition would have more negative implicit attitudes towards soda following EC. As seen in Hollands et al. (2011), we expected that individuals who had stronger negative baseline implicit attitudes towards soda would be less affected by the intervention because they would have less room for attitude change. Because previous research had shown that explicit attitudes are less affected by EC (Gawronski & LeBel, 2008; Hollands et al., 2011), we measured but did not make predictions regarding differences in explicit attitudes or in positive implicit attitudes that were not targeted by negative pairing. Because the ultimate goal of the study was to determine whether EC could facilitate reduction in soda consumption, behavioral measures were the primary outcomes. Exploratory analyses also examined changes in consumption of other sugar-sweetened beverages ("SSBs") across the follow-up period because increased SSB consumption to compensate for reduced soda intake could undermine the benefits of a soda EC on calorie intake and weight.

3. Methods

3.1. Participant enrollment

Participants were adult men and women recruited from the Drexel University community in the Philadelphia, PA metropolitan area. Permission to conduct this study was obtained from the Drexel Institutional Review Board. The study was described to potential participants as an investigation of the impact of visual images on the liking of non-diet soda. Potential participants ($N = 143$) completed a phone screen in which study personnel assessed inclusion and exclusion criteria. To qualify, individuals had to own a phone with regular web access, be able to attend a one-time study visit ($n = 12$ excluded), and report consuming at least 36 ounces of non-diet soda per week ($n = 12$ did not meet consumption minimum, $n = 6$ drank primarily diet soda). Individuals were excluded if they reported upcoming events likely to affect their diet (e.g. medical procedures requiring fasting, starting or stopping certain medications) or the intention to make dietary changes during the study period ($n = 2$ excluded). Interested individuals were also assessed for significant blood, injury, or injection fears, because it was unknown whether such fears might engender a greater reaction to the disgust unconditioned stimuli (USs) due to heightened fear, or a lesser reaction due to fear-driven avoidance (Olatunji et al., 2007), however no participants were excluded based on this criterion.

Screened individuals ($N = 104$) were not enrolled in the study until they also completed a pre-intervention assessment period that was used to confirm whether they drank the minimum amount of soda required for inclusion (36 ounces/week or at least 3 sodas and 24 ounces/week).[1] They were also required to demonstrate adequate compliance with the tracking procedure during that period in order to enroll. A total of 91 participants were enrolled in the study ($n = 3$ did not meet consumption minimum, $n = 11$ were noncompliant), and 84 were randomized to study condition ($n = 7$ did not attend study visit in which randomization took place). On average, randomized participants reported drinking 146.1 total ounces of regular soda ($SD = 92.3$, Range: 28.4–541.1) during the pre-intervention period, equivalent to 12 twelve-ounce cans per week ($M_{BMI} = 25.0$, $SD = 1.7\%$; see Table 1 for demographic information). See Fig. 1 for detailed enrollment information.

3.2. Procedure

3.2.1. Assessment

Participants completed two periods of tracking real-world soda consumption and one in-person assessment conducted at the time of the study intervention (i.e. the "study visit"). The tracking periods occurred for one-week before (i.e. pre-enrollment) and after the study visit. During each tracking period, participants were contacted three times per day via an automated text message service (SurveySignal; Hofmann & Patel, 2012) that connected them to an online survey containing questions about recent soda consumption. This process of prompting participants to report on a given behavior in the moment as they go about their daily lives is often referred to as ecological momentary assessment (EMA; e.g., Stone & Shiffman, 1994). Participants were required to respond to each prompt within 3 h of its receipt, after which time the link was no longer active. Participants completed a separate entry for every soda consumed since their completion of the previous prompt, and recorded the amount, brand, and whether the soda was diet or non-diet. Upon opening each prompt, participants who had missed the previous recording were given the opportunity to enter soda consumed during that one missed period only. This procedure was designed to allow for recovery of missing data without significantly diminishing the accuracy of reporting.

During the pre-enrollment period, participants were required to respond to 19 or more of the 21 EMA prompts (90.5%) to be eligible for the study. Participants who missed more than two prompts were given one opportunity to repeat the full pre-intervention period with adequate compliance before being removed from the study. Three participants were admitted on their second attempt. To encourage high compliance with the post-intervention EMA, study compensation was dependent on number of post-intervention responses (ranging from a choice of 5 dollars or one extra credit point for responding to 13 or fewer prompts, to 20 dollars or four extra credit points for 20 to 21 prompts).

During the study visit, tasks were completed in the following order: a) informed consent, b) questionnaire completion (including baseline explicit attitudes), c) baseline measurement of implicit

Table 1
Descriptive statistics and baseline comparisons between study conditions.

Variable	Total sample ($N = 84$)	EC ($n = 43$)	Control ($n = 41$)	t
Age	21.8 ± 4.0	21.7 ± 4.6	21.0 ± 3.4	0.85
BMI	25.0 ± 5.1	25.2 ± 5.0	24.7 ± 5.2	0.75
Regular Soda (oz.)	146.1 ± 92.34	133.2 ± 93.7	159.6 ± 90.0	1.60
Diet Soda (oz.)	5.1 ± 14.1	5.7 ± 13.6	4.5 ± 14.7	0.51
Explicit attitudes	31.7 ± 4.3	32.0 ± 4.0	31.4 ± 4.7	0.61
Implicit negative attitudes	0.09 ± 0.37	0.10 ± 0.38	0.08 ± 0.36	0.32
Implicit positive attitudes	0.24 ± 0.37	0.26 ± 0.35	0.23 ± 0.40	0.35
Variable	**N (%)**	**n (%)**	**n (%)**	**χ^2**
Ethnicity				
White	44 (52.4%)	28 (65.1%)	16 (39.0%)	7.79*
Asian/Asian American	27 (32.1%)	8 (18.6%)	19 (46.3%)	
Black/African	13 (15.5%)	7 (16.3%)	6 (14.6%)	
Relationship status				
Single	63 (75.0%)	33 (76.7%)	30 (73.2%)	1.36
Preferred Soda Brand				
Coke	40 (47.6%)	19 (44.2%)	21 (51.2%)	1.81
Pepsi	17 (20.2%)	10 (23.3%)	7 (17.1%)	
Sprite	18 (21.4%)	8 (18.6%)	10 (24.4%)	
Dr. Pepper	9 (10.7%)	6 (14.0%)	3 (7.3%)	
Intention to reduce soda consumption				
Yes	35 (41.7%)	15 (34.9%)	20 (48.8%)	1.67

Note. Regular and diet soda amounts are total ounces per week reported during the pre-intervention EMA. No individuals reported primarily drinking Mountain Dew. EC = Evaluative Conditioning Intervention, Control = Control Intervention. * Significant at $p < 0.05$.

[1] Amount consumed was used as an eligibility criterion because the effects of an intervention on infrequent soda consumers would be difficult to detect across a one-week follow-up period due to possible floor effects. This inclusion criterion was simplified during the phone screen (36 total ounces/week) to maximize the likelihood that screened participants would meet inclusion criteria.

attitudes, d) a distraction word-search task, e) intervention procedure, f) post-intervention measure of implicit attitudes, g) measurement of weight, and h) explicit attitude measure and taste-test (completed in a separate room).

Because differences in hunger, thirst, or recent soda consumption might also affect study measures, participants were asked to not eat or drink (other than water) within 2 h of the study visit, and to not drink water within 30 min. Questions about recent consumption embedded within the questionnaires indicated that all participants followed these instructions. Due to concerns that time of day might affect soda consumption (i.e., that soda is not conventionally consumed with breakfast), all study visits were conducted after 11AM, and visit time was recorded and tested as a covariate in taste test analyses. This variable was not found to significantly predict consumption or impact the statistical significance of other variables in the analysis, and it was therefore removed from the final results presented below.

3.2.2. Intervention

Intervention and IAT tasks were programmed using E-Prime Studio 2.0 for Windows, which recorded response times in milliseconds. The evaluative conditioning procedure was modeled after previous studies of the effect of EC on consumption (Houben, Havermans, et al., 2010; Lebens et al., 2011). A picture-picture EC task was used in which images of soda and water (CSs) were presented in one of the four quadrants of the computer screen. To limit awareness of the purpose of the task, participants were asked to respond to each CS based on its location (i.e., press the "i" if the image appeared in one of the two top quadrants and the "e" key if the image appeared in one of the bottom quadrants). This procedure was repeated for 120 trials with an inter-trial interval of 1500 ms. Of the 120 trials, half displayed soda CSs and half displayed water CSs.

In the EC condition, a US appeared in the same quadrant for 500 m following the participant's response. Soda CSs were always paired with disgust images, and water CSs were paired with positive images. The second image appeared regardless of whether or not the participant correctly responded to the first image's location. In the control condition, no pairing took place (i.e. no second image appeared following a response). Instead, participants responded directly to two sets of images in separate blocks – first to the CS images, then the US images. The use of separate blocks (rather than random pairing of CS-US images) was designed to avoid the possibility that a relatively strong affective response to the disgust images would alter implicit attitudes towards soda in spite of equivalent positive pairings.

3.2.2.1. Image selection. The images used in the study were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008; all positive US images and six disgust US images) and the internet (18 disgust US images and all CS images). A larger pool of US images (24) was selected in comparison to previous studies (typically six images) in order to prevent habituation to the disgust images. Positive USs were selected with the highest IAPS valence ratings, matched to the number of disgust images that featured food or people.

Both CS and disgust US images were piloted on a group of 86 volunteers. Negative images were piloted because IAPS norms do not feature disgust-specific ratings, and because some images featured graphic content and it was thought that distress-based aversion might interfere with the study procedure. Volunteers rated 100 IAPS and 50 internet images on level of disgust and degree to which they were disturbing or upsetting. Images with above-average distress ratings were excluded (above 3.5 on a 0–5 likert scale), and those with the highest disgust ratings were then selected as USs. Mean disgust ratings for the 24 selected images ranged from 0.8 to 2.6 on an 11-point Likert scale in which 0 represented "extremely disgusting," and 10 represented "pleasant."

Five sets of soda CS images were developed, each featuring one of the five most popular non-diet soda brands based on U.S. market share (Coca-Cola, Pepsi, Mountain Dew, Dr. Pepper, and Sprite). Both featured (i.e., including only that brand with brand logo visible) and generic images (i.e., images that also included other brands or depicted a glass of soda without visible brand logo) were included so that the images viewed would be targeted to the participants' drinking habits, yet still generalize to other soda types. Fifteen to 25 images featuring each brand were rated on representativeness by pilot participants who regularly drank the brand (i.e. indicated that they drank the brand at least once per month). Each CS image set included the three most representative brand images, as well as three images that were generic (i.e., no brand label) or contained multiple brands. Self-report items regarding brand preferences and relative frequency of their consumption were used to select the featured soda for each participant. The same water CS images and US images were used in every EC procedure.

3.2.3. Randomization

Participants were allocated to intervention condition, as well as to one of four versions of the IAT task (counterbalancing order and pairing), in blocks of eight by the principal investigator prior to the study visit. Participants completed the same version of the IAT at pre- and post-intervention. Assessors were blinded to participant assignment by using a coding system to label intervention programs. Order of presentation for sodas during the taste test from left to right was also assigned by the principal investigator using random integer sequences.

3.3. Measures

3.3.1. Primary outcome measures

3.3.1.1. Immediate soda consumption. Consumption was measured in the lab using a mock taste-test. Participants were presented with 12oz. servings of the five targeted soda brands, each in a clear drinking glass accompanied by a 20–24-ounce bottle showing the brand logo, and were asked to complete a survey rating the taste of each soda. A 12 oz. glass of water was also provided. Before and after the taste test, the assessor measured the weight in grams of each beverage, including water, using a food scale. Consumption was calculated as the difference between pre- and post-test beverage weights.

3.3.1.2. Follow-up soda consumption. Real-world soda consumption in ounces was tracked across the week before and after the study visit using EMA as described above.

3.3.2. Secondary outcome measures

3.3.2.1. Implicit attitudes. The Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) is a widely used measure for assessing implicit attitudes by asking participants to rapidly sort words or images between two stimulus and attribute categories. It is assumed that individuals respond faster when stimulus and attribute categories highly associated in memory are paired to the same response key. However, the IAT has been criticized because attitude strength towards one stimulus can only be interpreted relative to an opposing stimulus category (e.g., Penke, Eichstaedt, & Asendorpf, 2006). This is particularly problematic when there is no natural opposite category, as is the case with soda. The Single Category IAT (SC-IAT; Penke et al., 2006; Karpinski & Steinman, 2006) has been developed to address this problem by using only one stimulus category (e.g., "soda") and two attributes. Several studies have shown satisfactory internal consistency and predictive validity for the SC-IAT (Karpinski & Steinman, 2006; Schnabel, Asendorpf, & Greenwald, 2008). Two unipolar attribute categories (e.g. positive vs. neutral) were selected instead of a bipolar category (e.g. positive vs. negative) because previous studies suggest that individuals may harbor both negative and positive associations towards high calorie foods (Houben, Roefs, & Jansen, 2010).

Unipolar SC-IATs were modeled after those used in previous studies of implicit food attitudes (e.g., Houben, Roefs, et al., 2010; Lebens et al., 2011). In the positive SC-IAT, a positive attribute category (label: "pleasant"; attribute stimuli: tasty, delicious, nice, delightful, heavenly, enjoyable) was contrasted with a neutral attribute category (label: "neutral"; attribute stimuli: average, general, normal, typical, ordinary, indifferent). In the negative SC-IAT, the same neutral attribute category was contrasted with a negative attribute category (label: "unpleasant"; stimuli: unsavory, bad, nasty, awful, disgusting, gross). The soda stimuli were the same images featured in the intervention. Each SC-IAT consisted of 24 practice trials followed by 72 test trials in which soda images, words in the paired attribute category, and words in the non-paired category were presented in a 7:7:10 ratio in order to balance the percentage of correct responses assigned to each key (Karpinski & Steinman, 2006). The order of completion of the positive and negative SC-IATs, as well as the order in which participants completed neutral vs. valenced pairings within each SC-IAT, were counterbalanced across participants.

The SC-IAT effects were calculated using the D600 scoring algorithm (Greenwald, Nosek, & Banaji, 2003) such that higher scores indicate faster performance for the valenced versus neutral response assignment, and thus a more valenced implicit attitude. Error scores were penalized as the mean plus 600 ms, latencies over 10,000 ms were excluded from the analysis, and participants with more than 10% latencies under 300 ms were excluded (one participant; Greenwald et al., 2003). SC-IAT data from twelve participants could not be included in analyses due to a programing error in one version of the task.

3.3.2.2. Explicit attitudes. Participants responded to eight items by rating their attitudes along 6-point Likert scales (anchors "Not at all" to "Extremely") using the prompt "For me, drinking soda is …" (healthy, unhealthy, bad, good, enjoyable, unenjoyable, pleasant, and unpleasant). Item responses were averaged (reverse scored where appropriate) to create explicit ratings of each soda and of soda in general. Internal consistency was examined using Cronbach's alpha and found to range from 0.65 to 0.82 (acceptable to good) across administrations.

3.3.2.3. Additional information. Demographic and personal characteristics were collected using self-report measures during the study visit. BMI was computed from self-reported height and participants' measured weight. After completing the final prompt of each EMA period, participants were asked to report their weekly consumption in ounces of other SSBs (coffee, energy drinks, and "other"). Size references were provided (e.g., "a medium coffee is 16 oz.").

3.3.3. Manipulation checks

Prior to analysis, self-reported soda consumption habits were examined to confirm appropriateness to the study intervention. Although all individuals had reported frequent non-diet soda consumption during the screen and pre-intervention EMA, five individuals' self-report on measures (collected during the study visit) indicated that they always drank diet soda ($n = 4$) or non-soda (sparkling water, $n = 1$). These individuals may have observed that the study targeted regular soda drinkers and altered their responses so that they would be eligible to participate. Individuals reporting no regular soda consumption were excluded from EMA analyses only, because EC would be hypothesized to alter attitudes and behavior relevant to the target stimuli regardless of typical consumption patterns.

Because previous studies have found that attention predicts the strength of EC effects, even after controlling for its effect on contingency awareness (Field & Moore, 2005), we examined accuracy of participants' responses to image location during the EC task prior to data analysis as an indicator of inattention. Two individuals were identified as having error rates that differed significantly from the rest of the sample (errors on 38.3% ($z = 3.3$) and 48.3% ($z = 4.4$) of trials). Non-attenders were excluded from all analyses reported below. We repeated all analyses including the full sample, and the pattern of results was similar. Any cases in which the outcomes of interest differed in statistical significance in the full sample are described in footnotes below.

3.4. Statistical analysis

Prior to data analysis, variables were examined for indicators of normality and outliers. A square root transformation was applied to both soda and water outcomes from the taste test to correct skewness in these variables. Untransformed means are presented for ease of interpretation; however, analyses were conducted using transformed variables. One outlier was excluded from the long-term consumption analysis.[2] Across all analyses, interaction terms were computed as the product of centered variables. Except for where otherwise noted, no assumption violations were observed. All data were analyzed using SPSS 21.0 software, and the alpha level for all analyses was set at 0.05.

T-tests and chi square tests were used to compare conditions on baseline characteristics. Differences in taste test consumption were compared using a one-way ANCOVA controlling for time of study visit. Generalized estimating equation (GEE) models with an autoregressive (AR(1)) correlation structure were used to examine changes in real-world soda consumption (Zeger, Liang, & Albert, 1988). Time was modeled using both categorical (pre vs post-intervention) and continuous variables (day and time of day). Because of the high percentage of prompts in which 0 soda ounces were reported (60.8%), a Tweedie distribution using a log link function was specified (Tweedie, 1984).

Post-treatment differences in positive and negative implicit attitudes were tested using ANCOVAs adjusting for baseline attitudes. Hierarchical multiple regression was used to test whether baseline attitudes moderated the effect of EC on post-intervention implicit attitudes. In each regression, covariates were entered in the first block, followed by baseline implicit attitudes and condition in the second block, and their interaction in the third block. Differences between conditions in post-intervention consumption of diet soda and other SSBs were tested using 2 (time) x 2 (condition) ANOVAs.

4. Results

4.1. Baseline comparisons

Most variables did not differ significantly by condition prior to the intervention (Table 1). There was a higher percentage of white participants and lower percentage of Asian and Asian American

[2] One individual reported consuming 136 oz. of soda during a single recording period (prompt). This amount was twice as large as the next highest amount reported by any individual during the study period. All other scores recorded by this individual were included in the analysis.

Table 2
Total consumption during the taste test by condition in grams.

	EC *M* (*SE*)	Control *M* (*SE*)
Soda	320.6 (28.0)	240.5 (26.9)
Water	119.4 (16.1)	93.6 (15.5)

Note. Untransformed estimated marginal means adjusted for race. Values represent amount consumed in grams. EC = Evaluative Conditioning Intervention, Control = Control Intervention.

participants in the EC group, therefore all analyses were initially conducted including race as a covariate. Race showed a trend towards predicting taste test consumption ($p = 0.08$), but was not found to significantly predict any other primary or secondary outcome. The inclusion of this variable did not affect the statistical significance of any outcome of interest. Therefore, race was only included as a covariate for the taste test analysis in the final results reported below.

4.2. Study completion

Every participant who was randomized to study condition completed all components of the study visit. EMA completers were defined a priori as responding to 80% (17 of 21) of post-intervention prompts, and all participants met this definition. Out of all 3654 possible EMA data points, 117 scores (3.2%) were missed but recovered in the subsequent survey using missed prompt items, and 50 scores (1.4%) were missed and not recovered. Number of missed prompts did not differ significantly between conditions.

4.3. Soda consumption

4.3.1. Immediate consumption

There was an unexpected trend towards individuals in the EC condition consuming more soda than the control group during the taste test ($F(1,76) = 3.95$, $p = 0.05$, partial $\eta^2 = 0.05$; see Table 2).[3] Water consumption did not differ significantly between conditions ($p = 0.24$).

4.3.2. Long-term consumption

The conditions differed significantly in change from pre-to post-intervention (Wald $\chi^2 = 5.03$, $p = 0.03$).[4] There were also significant main effects for study condition (Wald $\chi^2 = 6.99$, $p = 0.01$), and change from pre-to post-intervention (Wald $\chi^2 = 6.90$, $p = 0.01$). Post-hoc comparisons revealed a reduction in soda consumption from pre-to post-intervention in the EC condition (Wald $\chi^2 = 10.88$, $p = 0.001$), but not in the control condition (Wald $\chi^2 = 1.68$, $p = 0.20$; Fig. 2).

4.3.3. Other beverage consumption

There were no significant effects of time (i.e., change from pre-to post-treatment), condition, or their interaction on the diet soda, coffee, energy drink, or other sugar-sweetened beverage outcomes (Table 3).

[3] The difference between conditions was not statistically significant when all participants were included in the analysis ($F(1,77) = 2.35$, $p = 0.13$, partial $\eta^2 = 0.03$).

[4] The difference between conditions only reached the trend level when individuals with high error rates during the EC task were included in the analysis (Wald $\chi^2 = 3.61$, $p = 0.06$) or when all participants were included (Wald $\chi^2 = 3.10$, $p = 0.08$, including those with high error rates and those who reported never drinking regular soda). Post-hoc comparisons revealed significant change in the EC condition but not the control condition across all analyses.

4.4. Implicit attitudes

4.4.1. Post-intervention attitudes

Although negative attitude scores appeared stronger in the EC group at post-treatment, there were no significant differences between conditions after controlling for baseline scores (Table 4). Positive implicit attitudes and explicit ratings of soda also did not differ between conditions after controlling for their respective baseline values.

4.4.2. Moderation of baseline negative attitudes

Baseline negative attitudes moderated the effect of condition on post-treatment negative implicit attitudes ($R^2_{change} = 0.07$, $F(1,72) = 6.47$, $p = 0.01$). Contrary to the hypothesized result, negative post-intervention attitudes towards soda were stronger in the EC group than the control group among individuals who had higher pre-intervention negative implicit attitudes ($b = 0.38$, $SE = 0.13$, $\beta = 0.44$, $t(72) = 2.92$, $p = 0.005$), but not for those who had average ($b = 0.15$, $SE = 0.10$, $\beta = 0.17$, $t(72) = 1.60$, $p = 0.11$) or weaker ($b = -0.09$, $SE = 0.13$, $\beta = -0.10$, $t(72) = -0.68$, $p = 0.50$) baseline negative attitudes towards soda (Fig. 3).

5. Discussion

The present study examined whether an EC procedure in which soda CSs were paired with disgust and water CSs were paired with pleasant images could alter short and long-term consumption and increase negative implicit attitudes towards soda. The benefits of the intervention relative to a no-pairing control were mixed. Individuals in the EC condition did not consume less soda than control participants during a taste test immediately following the intervention, but did experience a greater reduction in soda consumption over the one-week follow-up period. Implicit attitude change was found to be strongest among individuals who held negative attitudes towards soda prior to the intervention.

5.1. Taste test consumption

Surprisingly, mean consumption during the taste test tended to be higher in the EC group, though this difference was small and did not cross the threshold for statistical significance. This might indicate that EC did not have the hypothesized effect on short-term consumption. Only two previous studies have examined effect of an implicit attitude intervention using a taste test. Houben, Schoenmakers, and Wiers (2010) found that negative pairing using EC led to lower alcohol consumption than a no pairing control. On the other hand, Haynes et al. (2015) did not find an overall difference between positive and negative pairing conditions on snack food consumption, but did find that awareness of the taste test purpose (e.g., that intake would be measured) moderated results and predicted a trend ($p = 0.06$) towards higher consumption in the negative pairing condition that might be attributed to reactance to experimental expectations. It is unlikely that such reactance occurred in the Houben et al. study, because the taste test was presented as part of a separate study and no participants identified a link between the two procedures. The present study's procedure parallels that of Hayes et al., so it is possible that some participants predicted that their consumption would be measured and altered their consumption due to perceived expectations. Unfortunately, awareness of taste test purpose was not measured, therefore we could not investigate its effect on the pattern of results.

It is also possible that requiring consumption of a beverage that had been associated with disgust contributed to higher consumption in the EC condition. Disgust is an emotion associated with disease and contamination that elicits a feeling of revulsion and

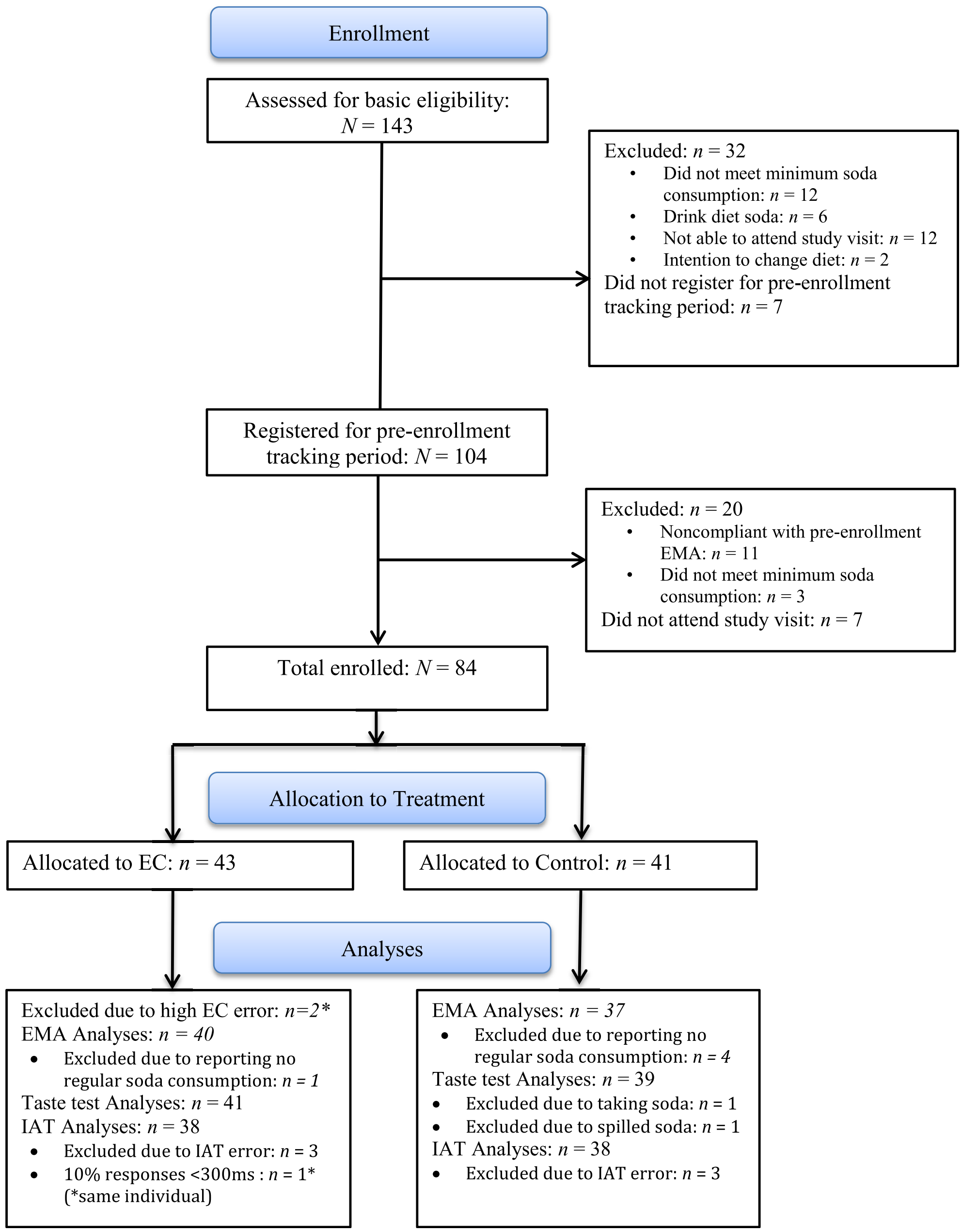

Fig. 1. CONSORT flow-chart.

desire to avoid the eliciting stimulus (Oaten, Stevenson, & Case, 2009). During the taste test, all participants were required to taste and rate five sodas immediately following the EC procedure, and were not given the option to avoid consuming the soda. Cognitive dissonance theory posit that stress or discomfort is experienced when an individual acts in a way that is inconsistent with his or her attitudes and beliefs. Consuming soda in the presence of a disgust association may therefore have produced such discomfort. Emotional distress has been found to induce overeating, particularly in restrained eaters (Stroebe, 2008). It is possible that some individuals in the EC condition experienced similar disinhibition when consuming soda in the context of a salient disgust association, leading them to drink more soda and water during the taste test. Future research investigating the effect of EC on consumption might seek to measure dissonance when the target food is first tasted, particularly because such dissonance might affect subsequent attitude change. It would also be useful to investigate whether giving participants the option to either taste or avoid the food or beverage produces a different pattern of consumption.

5.2. Effect of EC on behavior across a one-week follow-up period

Reduction in soda consumption from pre to post-intervention in the EC condition (43.3[5] fewer ounces per week) was 1.8 times greater than that of the control condition (24.0oz[4] fewer ounces). It is plausible that a reduction of 3.6 sodas per week, which

[5] Calculated by multiplying modeled mean differences from pre to post in average consumption per prompt for each condition by total number of prompts per week.

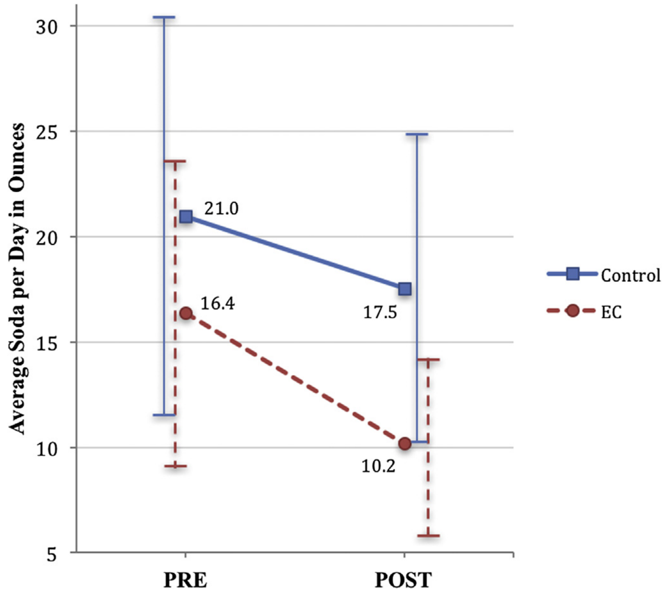

Fig. 2. Average consumption of regular soda per day by condition during the pre- and post-intervention periods ($n = 77$). Values at pre- and post-represent mean consumption per day across that period for each condition (untransformed estimated marginal means) and error bars represent the standard error of each estimate. Note that because untransformed means and SEs are displayed, the variability appears high due to the substantial percentage of prompts in which no soda was consumed. When the appropriate distribution is specified (Tweedie), the conditions differ significantly at post-treatment (Wald $\chi^2 = 8.19$, $p = 0.004$, 95% CI for mean difference (transformed) 0.17–0.92). EC = Evaluative Conditioning Intervention, Control = Control Intervention.

Table 4
Differences in post-treatment attitudes by condition.

	EC	Control	F (η^2p)	p
	M (SE)	M (SE)		
Negative IAT	0.18 (0.07)	0.03 (0.07)	2.31 (0.03)	0.13
Positive IAT	0.18 (0.06)	0.24 (0.06)	0.50 (0.01)	0.48
Explicit	29.2 (0.57)	29.9 (0.56)	0.73 (0.01)	0.40

Note. Estimated marginal means adjusted for baseline attitudes and race. IAT = Implicit Association Test. η^2p = partial eta squared.

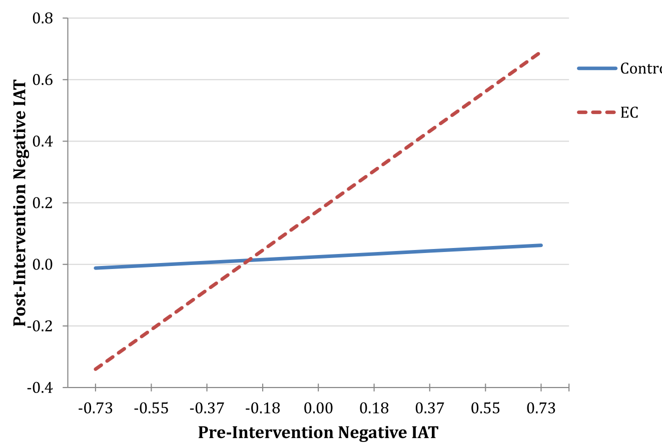

Fig. 3. Effect of EC on negative implicit attitudes depends on pre-intervention level of negative attitudes. X-axis values are centered ($M_{\text{pre IAT}} = 0.09$) and markers represent half a standard deviation. IAT = Implicit Attitude Test. EC = Evaluative Conditioning Intervention, Control = Control Intervention.

represents an intake of approximately 540 kcal, if sustained, would have a meaningful impact on calorie intake and body weight over time. Notably, individuals did not increase their consumption of diet soda or other sugar-sweetened beverages in response to these reductions, which is consistent with the results of behavioral interventions targeting soda consumption (Hu, 2013).

As referenced above, participants in the control condition also reduced their consumption across the intervention, though the amount of reduction was not statistically significant in that group. This may suggest that demand characteristics contributed to the size of reduction seen across conditions. All participants were told during the consenting process that the study purpose was to examine the effect of visual images on soda consumption, therefore some individuals may have expected a reduced desire to consume soda following the intervention and adjusted their consumption accordingly. It is also possible that reporting fatigue reduced participants' accuracy of reporting when responding to study prompts later in the EMA period. We therefore cannot be certain about the size of expected reduction in real-world consumption following EC.

When individuals with high error rates in the EC task and those who reported never drinking regular soda were included in the analysis, the pattern of the result was very similar in that the EC condition, but not the control, showed a significant reduction in consumption from pre-to post-intervention. However, the interaction between time and condition only reached the trend level when these individuals were included. Individuals who do not drink regular soda would be expected to benefit less from an intervention targeting regular soda drinking, and participants were required to report regular soda drinking to be eligible for the study. However, it is possible that several individuals perceived that the study targeted regular soda drinkers and altered their responses accordingly. The two participants that were excluded based on relatively high EC error rates may have benefitted less from the intervention due to inattentiveness, as seen in previous studies (Field & Moore, 2005). Notably, one of these individuals also met the standard criterion for exclusion used for IAT scoring (more than 10% latencies under 300 ms). Although we believe that these seven individuals were not appropriate to the intervention, we also must also allow that the weaker effects seen in when this group was included could indicate that EC is less effective for some individuals.

Overall, these findings parallel those of the two previous studies that measured the effects of EC across a one-week follow-up (Houben, Havermans, et al., 2010; Houben, Schoenmakers, et al., 2010), and enhance the strength of this evidence by using EMA rather than retrospective report to measure consumption. However, the interpretation of the results of the present study may be

Table 3
Change in other beverage consumption from pre-to post-intervention by condition.

	Condition	Time	Time × condition
Diet soda	Wald $\chi^2 = 0.39$, $p = 0.54$	Wald $\chi^2 = 2.29$, $p = 0.13$	Wald $\chi^2 = 0.05$, $p = 0.83$
Coffee	$F = 1.12$, $p = 0.29$	$F = 1.97$, $p = 0.17$	$F = 0.14$, $p = 0.71$
Energy drinks	$F = 0.22$, $p = 0.64$	$F = 0.23$, $p = 0.63$	$F = 0.30$, $p = 0.59$
Other sugar-sweetened beverages	$F = 0.01$, $p = 0.95$	$F < 0.001$, $p = 0.99$	$F = 0.002$, $p = 0.97$

limited by baseline differences between conditions. Although pre-intervention differences in soda consumption did not reach statistical significance, consumption was lower in the EC condition across the study and a significant main effect of condition was identified in the post-treatment model. It will therefore be important to replicate the present results, as well as to follow participants for a longer period to be better able to determine how long intervention effects might last.

5.3. Effect of EC on implicit attitudes

Negative implicit attitudes were expected to be stronger following the EC intervention, which was designed to increase the strength of soda–disgust associations. This effect only reached statistical significance among individuals who had relatively stronger baseline negative attitudes towards soda. Overall attitude change might have been weaker in this study because the target CSs were branded, well-advertised beverages and participants were regular CS consumers and therefore would be expected to have a strong network of existing CS attitudes. In general, meta-analysis has shown that the effects of EC are larger when the CS is unfamiliar or neutral in attitude valence (Hofmann et al., 2010). It may be the case that the effect of a brief pairing procedure is even weaker in mature brands in comparison to general familiar stimuli. Meta-analysis has also identified that contingency awareness enhances the strength of EC effects (Hofmann et al., 2010), therefore masking the purpose of the EC intervention by using a spatial location task may have further weakened EC effects. Individual levels of contingency awareness were not measured in this study, which limits our ability to explore moderation effects.

The moderating effect of baseline attitudes was in the opposite direction of the Hollands et al. (2011) study, which found a greater post-intervention implicit preference for fruit versus snacks among individuals with a weaker initial preference for fruits and hypothesized that a ceiling effect prevented post-intervention differences from emerging among individuals who already had strong implicit preferences for fruit. Gibson (2008) also examined moderation of baseline attitudes, and identified that EC only shifted implicit attitudes towards Coke versus Pepsi among individuals who initially had no strong preference for either brand. Methodological differences make it difficult to compare the present findings directly to these studies. Both studies used standard IATs in which attitudes were measured on a bipolar spectrum relative to an opposing stimulus, whereas the present study used unipolar SC-IATs to isolate negative soda attitudes. Because bipolar scales do not allow for the possibility that an individual might possess both positive and negative attitudes towards the same stimulus (isolated when using unipolar scales), it is unknown whether individuals with high unipolar negative attitudes would score in the negative, neutral, or even positive range if measured on a bipolar scale or how relative attitude strength would be affected if soda had been contrasted with another beverage.

It is also possible that the moderating effects differed in this study because participants were more likely to have strong pre-existing attitudes towards the CSs compared to previous studies in which participants were not required to be regular consumers of the target CSs. Although EC is hypothesized to work through creating associations with a given affective response, it has been argued that adding a few novel associations is unlikely to override an existing associative network, and that in the case of familiar CSs, EC may instead work through shifting the salience of previously existing affective associations (Gawronski & Bodenhausen, 2006; Gibson, 2008). This theory would suggest that in the present study, the EC procedure primed negative associations with soda among individuals who already held such associations, but was not strong enough to override more uniformly positive associations.

5.4. Overall conclusions

Overall, the results of the present study indicate that EC has the potential to affect real-world consumption across one week or more. Although it is important to better understand why EC produced a non-significant increase in consumption when soda was tasted immediately following the procedure, the longer-term naturalistic measure of consumption is likely to better reflect EC's potential to facilitate eating behavior change. Implicit attitude outcomes suggest that the observed reductions in consumption may be related to increased salience of pre-existing negative attitudes towards soda, and that a more intensive intervention would be required to change attitudes towards a regularly consumed brand in individuals who do not already hold negative affective associations. However, it is also possible that the mixed support for behavioral and attitude hypotheses indicate that the effects of EC are either weak or unreliable, and replication will be necessary before we can draw strong conclusions about its potential impact.

Among the strengths of this study were the use of both an objective measurement and EMA to assess behavioral outcomes, both of which afford greater confidence that the effects seen in this study reflect real behavioral differences than would self-report measures. The high compliance rates during the EMA periods represent a significant methodological strength. Additionally, the images selected for use in the current study were piloted by a large group of participants, and we combined these ratings with self-reported consumption to tailor the CS stimuli to each individual's real-world drinking habits. Although meta-analysis of EC suggests that tailored stimuli may strengthen effects (Hofmann et al., 2010), it would be useful to directly compare EC procedures featuring CS stimuli selected in this manner to generic and individual-selected CS stimuli. Previous research also supports the selection of disgust US images as a potential procedural strength. Disgust has been shown to produce stronger conditioning effects for food/beverages because it shares a relevant connection to those stimuli (Verwijmeren et al., 2012), and has been shown to be more resistant to extinction than distress and fear-related stimuli (Olatunji et al., 2007). It would again be useful for future studies to directly compare the effects of other negative images to disgust-evoking images, particularly to determine whether disgust associations are more likely to produce a disinhibitory effect when food is tasted.

Although the use of unipolar SC-IATs was also considered to be a strength because this measure isolated negative affective associations towards soda, it may also have proved a limitation because affective changes related to water, which was also targeted in the current EC procedure, were not measured. The use of SC-IATs also made it more difficult to compare the present results to previous studies that used traditional IATs. The lack of measures of contingency awareness, which has been shown to impact the strength of EC effects (e.g. Hofmann et al., 2010), also limited our ability to test possible sources of weaker overall attitude change in this study relative to previous studies. Future research might address these issues by using both single category and bipolar IAT measures and including measures of contingency awareness. As noted above, awareness of the taste test purpose may also have impacted the short-term behavioral results, and future research might both measure this awareness and better mask the relationship between the taste test and intervention procedures.

Overall, the results of this study suggest that a disgust-based EC has the potential to impact dietary habits, possibly through evoking existing negative associations with the targeted food. Additional research is needed to confirm the reliability of these effects and clarify the impact of procedural and stimulus selections. It will be important to then extend the length of the follow-up period to determine whether and for how long any effects on consumption can be maintained, and to assess whether that duration could be extended by repeating the intervention procedure.

If findings continue to support the effect of EC on real-world consumption, it could be used as an adjunctive intervention to reduce the need for dieters to rely on self-control when attempting to reduce their consumption of calorie-dense foods. These interventions could be offered to the public either via the availability of online pairing programs for use by individuals interested in reducing their consumption, or by implementing pictorial warnings on soda packaging.

Before developing an intervention for public use, it will be important to determine whether disgust pairings consistently produce short-term increases in consumption when soda is tasted. If this were the case, it would not be appropriate to include such images on soda packaging. Additionally, like with proposed soda taxes, pictorial warnings are likely to be resisted by soft drink producers and policy-makers concerned about the images' impact on sales, personal freedom, or unintended consequences such as the possibility that individuals would increase consumption of other high-calorie beverages (e.g., Edwards, 2011). On the other hand, several countries have introduced requirements for similar pictorial warnings on cigarette packaging in the past 5 years, often despite legal challenges (e.g., Lencucha, Labonte, & Drope, 2015). In experimental studies, these packages have been shown to reduce the appeal of cigarettes, the price that smokers are willing to pay for them, and the likelihood of accepting a pack of cigarettes as a reward (see Martin, 2014 for review). However, implementation in other countries has stalled, with policy-makers citing a lack of strong evidence of behavioral effects. A recent systematic review (Monarrez-Espino, Liu, Greiner, Bremberg, & Galanti, 2014) found that pictorial messages may produce reductions in number of cigarettes smoked and increase the likelihood of making a quitting attempt, but concluded that the evidence for these effects was still inadequate due to heterogeneity of study methodology and quality. This highlights the importance of continuing to include measures of behavior change, particularly as applied to naturalistic behavior, in future studies investigating the effect of negative image pairings.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2016.05.016

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