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Setting a goal could help you control: Comparing the effect of health goal vs general episodic future thinking on health behaviors among cigarette smokers and obese individuals

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Abstract

Episodic Future Thinking (EFT) reduces delay discounting (DD; preference for smaller, immediate rewards) and various maladaptive behaviors. Exploring potential personalization of EFT to optimize its ability to alter DD and demand for unhealthy reinforcers is important for the development of interventions targeting long-term improvement and maintenance of health. In this investigation, using two separate studies, we examined the effects of EFT with and without a health goal on rates of discounting, demand, and craving for cigarettes and fast food among

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cigarette smokers and obese individuals, respectively. Using data collected from Amazon Mechanical Turk (mTurk), Study 1 (*N*=189) examined the effect of EFT on DD and measures of cigarette demand and craving in cigarette smokers who were randomly assigned to one of three conditions: EFT-health goal, EFT-general, or Episodic Recent Thinking (ERT)-general. Study 2 (*N*=255), using a 2×2 factorial design, examined the effects of health goals and general EFT on DD and measures of fast food demand and craving in obese individuals who were randomly assigned to one of four conditions: EFT-health goal, EFT-general, ERT-health goal or ERT-general. Health-goal EFT was not more effective than general EFT in reducing monetary discounting. However, the addition of a health goal to general EFT was significantly associated with higher effect on intensity and elasticity of demand for cigarettes and fast food compared to EFT without a health goal. These findings suggest that the amplification of future thinking through the inclusion of a health goal may promote healthy decisions and result in positive behavior changes.

Keywords

delay discounting; episodic future thinking; health goals; cigarette smoking; obesity; Fast food

Worldwide, the most significant risk factors for death are tobacco use (GBD 2015 Risk Factors Collaborators, 2016; World Health Organization, 2009) and consequences associated with obesity such as high blood pressure, blood glucose, and body mass index (BMI). For example, long-term smoking can contribute to a variety of health issues, including chronic obstructive pulmonary disease (COPD), various cancers, and coronary heart disease (National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2014). Similarly, obesity incurs a heightened risk of various health comorbidities such as type 2 diabetes mellitus, hypertension, respiratory disorders, and arthritis (Mokdad et al., 2003). However, these two risk factors are modifiable with effective interventions.

According to the behavioral economic concept of reinforcer pathology, both smoking and obesity, along with a number of other behavioral risk factors for disease, share two common behavioral characteristics: (a) excessive preference for short-term rewards at the expense of delayed, future outcomes and (b) excessive valuation and demand for an unhealthy reinforcer (e.g., cigarettes, fast food; Bickel, Jarmolowicz, Terry Mueller, & Gatchalian, 2011; Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014; Carr, Oluyomi Daniel, Lin, & Epstien, 2011). Preference for short-term rewards can be assessed with delay discounting (DD), a behavioral marker of addiction (Bickel, Koffarnus, Moody, & Wilson, 2014; Silva Castillo & Castillo, 2017; Story, Vlaev, Seymour, Darzi, & Dolan, 2014), and valuation of a reinforcer can be assessed with the demand purchase task (Jacobs & Bickel, 1999; MacKillop et al., 2008; Sze, Stein, Bickel, Paluch, & Epstein, 2017). Interventions that decrease rate of DD and/or decrease demand for an unhealthy reinforcer may control negative habits and promote positive health behaviors.

An emerging approach for the reduction of DD is episodic future thinking (EFT; Benoit, Gilbert, & Burgess, 2011; Daniel, Said, Stanton, & Epstein, 2015; Daniel, Stanton, & Epstein, 2013a, 2013b; Lin & Epstein, 2014; Peters & Büchel, 2010). EFT reflects the

capacity to vividly imagine personal experiences that could realistically occur in one's future (Atance & O'Neill, 2001; Terrett et al., 2016). EFT is believed to decrease DD by guiding individuals to contemplate possible future outcomes during intertemporal decision making, thereby shifting the temporal perspective from the present towards the future (Atance & O'Neill, 2001; Daniel et al., 2015; O'Donnell, Oluyomi Daniel, & Epstein, 2017). Previous studies have indicated an effect of EFT on reducing the valuation of unhealthy reinforcers. For example, EFT has been shown to reduce cigarette smoking (Chiou & Wu, 2017; Stein, Tegge, Turner, & Bickel, 2018; Stein et al., 2016), cigarette purchasing (Stein et al., 2018), alcohol purchasing (Bulley & Gullo, 2017; Snider, LaConte, & Bickel, 2016), and caloric intake in obese women (Daniel et al., 2013a) and children (Daniel et al., 2015), as well as food purchasing (Hollis-Hansen, Seidman, O'Donnell, & Epstein, 2018; Sze et al., 2017). Typically, EFT is induced by guiding participants to imagine and describe positive, personal future events, without additional restrictions on the content of these events. Given that an individual may be more impulsive for a specific reinforcer (e.g., cigarettes, food) but not for another (e.g., alcohol), personalizing and tailoring EFT to the behavior of interest (e.g., quitting smoking, eating healthier) may be beneficial in amplifying the capacity of EFT to change that specific behavior.

Research suggests that EFT aids cognitive functions such as goal-attainment and future planning (D'Argembeau, Lardi, & Van der Linden, 2012; Schacter, Benoit, & Szpunar, 2017) and thus is often oriented towards future goals (D'Argembeau et al., 2010). Previous experiments have demonstrated that EFT events related to future financial goals (e.g., "In two weeks I am purchasing a new computer") led to reduction in monetary DD beyond that of general EFT events (e.g., "In two weeks I am going home for the weekend"; O'Donnell et al., 2017). Moreover, goal-related future thinking leads to heightened activation of brain structures commonly involved in planning and prospection (D'Argembeau et al., 2010; McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007). Goal-oriented EFT has also been shown to be more salient and emotional than non-goal EFT cues, providing further evidence for the enhanced capacity of goal-oriented EFT to reduce DD (O'Donnell et al., 2017). Indeed, these findings suggest that goal-related EFT is an area of exploration which may have substantial implications in future behavioral treatments.

Exploring potential personalization and tailoring of EFT to individual's characteristics and needs to optimize its ability to alter DD and demand for unhealthy reinforcers has significant ramifications for the development of interventions that target improvement and long-term maintenance of health. For example, tailoring EFT to one's level of impulsivity, personal goals, or fundamental motives may increase EFT's generalizability, efficacy, and/or efficiency in altering behaviors and improve treatment outcome. Outcome-specific EFT (e.g., food-related EFT for food consumption tasks) has been effective in altering DD and other health-related measures, with food-related EFT decreasing caloric intake in a laboratory eating task (Dassen, Jansen, Nederkoorn, & Houben, 2016). Similarly, health goal-related EFT has been effective in reducing calories purchased in an online grocery shopping simulation; however, goal-related EFT did not decrease the number of calories purchased beyond that of general EFT (Hollis-Hansen et al., 2018). Given the mixed results on the effect of incorporating health goals into general EFT on decreasing DD and the lack of comprehensive research concerning the impact of health goals on demand for

commodities other than food, further research investigating the benefit of adding a health goal component to the general (i.e., not explicitly goal-oriented) EFT is needed to yield conclusive evidence.

The current investigation, in two separate studies, examined the effectiveness in reducing DD of EFT events personalized to one's future health goals (EFT-health goal) versus the general EFT (EFT-general) events that were not otherwise related to health goals. Additionally, the effects of health goal and general episodic thinking on the valuation of reinforcers using a hypothetical purchase task were examined. In Study 1, Episodic Recent Thinking (ERT)-general, that was not related to health goals, was used as a control condition. Similar to EFT, ERT engages episodic memory, prompts imagination of real-life events, includes personal details, and produces vivid episodic imagery. However, ERT events occur in the recent past (Lin & Epstein, 2014; Stein et al., 2016) whereas EFT events are in the future. Hence, ERT controls for episodic thought, but does not involve prospection as a control for EFT. Two control conditions were established in Study 2: ERT-health goal which included a health component, and ERT-general. Within the ERT-health goal group, participants created health-related events from the prior three days to control for the act of generating and reading health goal cues. Study 1 assessed the impact of EFT-health goal and EFT-general compared to ERT-general on DD, cigarette valuation, and cigarette demand among 189 cigarette smokers (70 females). Study 2 sought to validate and extend the results of Study 1 by assessing the impact of EFT-health goal and EFT-general compared to ERT-health goal and ERT-general on DD, fast food valuation, and fast food demand among 255 obese individuals (151 females).

General Methodology

Participation in both studies was voluntary. Consent was implied through the completion of the survey. The analytical plan for both studies was determined and specified before the data collection. Both studies were approved by the Institutional Review Board (IRB) at Virginia Polytechnic Institute and State University.

Participants and Study Design

Both studies were conducted using data collected online on the Amazon Mechanical Turk (mTurk) platform, a crowdsourcing site through which participants can complete Human Intelligence Tasks (HITs) in return for monetary compensation. The current study used a medium effect size ($f = 0.25$, $\eta_p^2 = .06$) to inform the sample size of both studies assuming a type 1 error rate of 0.05 and 80% statistical power. Hence, a total of 159 and 189 participants were needed to complete Study 1 and Study 2, respectively. Eligibility was assessed using a short screening questionnaire. To meet eligibility requirements, participants in both studies were required to (1) be located in the United States and (2) have a HIT approval rating greater than 90%. In addition, participants in Study 1 were required to (a) report smoking more than 20 cigarettes a day and (b) answer "yes" to the question "Are you interested in cutting down or quitting cigarette smoking?", while participants in Study 2 were required to (a) have a BMI (kg/m^2) in the obese range (>=30) and (b) answer "yes" to the question "Are you interested in personal weight loss?" As data collection for the two studies occurred two

months apart, participants were permitted to be part of both studies if they met the eligibility criteria for both. Eleven participants completed both studies and were included in the analysis. By randomization, six of the 11 participants were assigned two opposite groups (EFT vs ERT) in the two studies. Participants in either study were excluded from the analysis if they failed the DD-specific attention check question, embedded within the DD tasks (i.e., selected "$0.00 now" when prompted "Which of the following would you prefer: $100 in 1 day or $0.00 now?"). Compensation for both studies was $3.00 for completion of the survey, which took approximately 30–45 minutes to complete. Additionally, participants were compensated an additional $3.00 if they passed the attention check question.

Study 1

Methodology

One hundred eighty-nine cigarette smokers who met the eligibility criteria were randomly assigned to one of three conditions (EFT-health goal, EFT-general, or ERT-general) in a between-subjects experimental design. All participants passed the attention check question and were included in the analysis. Participants answered a brief demographic questionnaire, generated the assigned events (i.e., EFT-health goal, EFT-general, or ERT-general), and completed an adjusting-amount discounting task (Du, Green, & Myerson, 2002). After, participants completed an assessment of cigarette craving and a cigarette purchase task which were given in random order.

Study Procedure and Measures—Various demographic data including age, annual income, gender, race, ethnicity, education level, and the number of cigarettes smoked daily (see Table 1) were collected using a standardized questionnaire.

Episodic events generation: EFT and ERT events and corresponding textual cues were generated using a self-guided, computerized generation task (Sze et al., 2017). EFT participants were instructed to imagine and carefully describe in detail seven positive, specific, and vivid future events (big or small) which they were looking forward to at each of seven delays in the future: 1 month, 3 months, 1 year, 2 years, 4 years, 8 years, and 16 years. In the EFT-health goal condition, in addition to the standard EFT-general instructions, participants were asked to link their cues at each of the seven delays with a health goal. Specifically, participants in the EFT-health goal group were instructed to associate their events with any health goal that they were looking forward to (did not have to be related to quitting smoking but could be). To assist in generating events with a health goal component, examples were provided describing positive health-related goals (e.g., "In about 1 year, I am on a family vacation and people are complimenting my glowing skin and healthy look"). For the control (i.e., ERT-general) condition, participants were instructed to list and describe in detail seven positive, specific, and vivid past events (big or small) that they had enjoyed in the previous three days (between "earlier this morning" and "three days ago").

Participants in each group were instructed to describe the events as though they were occurring in the present moment and were prompted to provide specific details of their events such as who they were with, where the event occurred, how they felt, and what was happening at the time. In addition, they were provided with examples of correct (detailed

and positive) and incorrect (vague and negative) events and explanations of the differences between them to highlight the importance of positivity, vividness, and specificity when generating events. Moreover, participants in all groups were asked to rate (from 1-not at all to 5-very much) the valence (enjoyment), salience (importance), arousal (excitement), and vividness of the events they created.

Adjusting-amount discounting task: Delay discounting was measured using an adjusting-amount discounting task which determines the monetary amount at which the immediate reward is valued equally to the $100 reward delivered after a delay. The value of the immediate reward was adjusted as participants made their choices (the value of the immediate reward increased if the delayed reward was chosen and decreased if the immediate reward was chosen) until the individual's indifference point was reached (see Du, Green, & Myerson, 2002). The indifference point calculated by averaging the last chosen alternative and the last rejected alternative demonstrates the degree to which the delayed reward ($100) has been discounted (e.g., an indifference point of $60 indicates that the delayed $100 reward has been discounted by 40%). This titration process was repeated at seven delays (1 month, 3 months, 1 year, 2 years, 4 years, 8 years, 16 years) with six trials at each delay. The area under the curve (AUC), used to calculate the level of discounting, refers to the area under the discounting function calculated by forming trapezoids from the indifference points (Myerson, Green, & Warusawitharana, 2001). The higher the discounting level, the smaller the AUC will be. Conversely, the lower the discounting level, the larger the AUC will be.

At each delay during the task, the corresponding self-generated EFT event cues were presented on the screen (i.e., one-month cues were paired with the one-month future delay). For ERT-general participants, each consecutive event in the past was presented alongside the following future delay (i.e., "early today" event cues with the one-month delay or "yesterday in the evening" event cues with the three-month delay). Participants were instructed to read and imagine the event cues carefully as they made their decisions. Given that EFT often decreases the rate of discounting and, as a result, DD data may violate assumptions (i.e., discounting might deviate from a monotonic function or individuals may show minimal or no discounting across delays; Stein et al., 2016) we did not exclude participants whose discounting did not meet the standardized criteria (Johnson & Bickel, 2008).

Cigarette purchase task: The cigarette purchase task is a hypothetical-scenario task measuring cigarette demand that has been validated in assessing the relative reinforcing value of nicotine for cigarette smokers (Jacobs & Bickel, 1999; MacKillop et al., 2008). Participants were prompted to indicate the number of cigarettes they would purchase to consume over the following 24-hour period at escalating price points per cigarette: $0.00, $0.03, $0.06, $0.12, $0.25, $0.50, $1.00, $2.00, $4.00, $8.00, $16.00, $32.00, and $64.00. During the task, participants were asked to assume that: (1) cigarettes available for purchase were their usual brand; (2) no other access to cigarettes or other nicotine products would be available; (3) purchased cigarettes would be smoked over the next 24 hours without the ability to save or stockpile them; and (4) purchased cigarettes could not be shared or given away. At each increasing price point, participants were presented with a randomly-selected

textual episodic cue from their generated list and asked to vividly imagine the event while making their decisions.

The purchase data were assessed for non-systematic purchasing using standard diagnostic criteria (Stein, Koffarnus, Snider, Quisenberry, & Bickel, 2015) prior to analysis. Non-systematic purchasing data may be a reason of failure to understand task instructions (e.g., purchases cannot be shared and must be consumed in a 24-hour period), not paying attention to prices (e.g., purchasing 5 cigarettes when each costs $0.00 and 40 cigarettes when each costs $64.00), or errors in response entry. The demand data of those who violated the Stein et al. criteria were excluded from purchase task analysis but included in all other analyses (total excluded N=55, EFT-health goal n=25, EFT-general n=12, ERT-general n=18). The frequency of non-systematic purchase data did not differ significantly by group (χ^2 (1, 189) = 3.952, p = 0.139). A consort diagram displaying which specific purchasing criteria (Stein et al., 2015) were violated for those excluded from demand analysis from the three groups is shown in Figure 1.

An estimate of demand curves was created by fitting purchases across the range of prices to the exponential demand curve equation using least square nonlinear regression that was performed using Prism (version 8, GraphPad Software, Inc, CA, US):

$$Q = Q_0 * 10^{k(e^{-\alpha Q_0 C} - 1)}$$

in which Q represents the quantity of a commodity consumed at price C, Q_0 is the quantity consumed at price $0.00, k is the range of cigarette consumption in $\log_{10}$ units, and α is the sensitivity of changes in cigarette consumption relative to increases in cost (Koffarnus, Franck, Stein, & Bickel, 2015). We used the cigarette purchase task to generate two demand indices: intensity (i.e., Q_0, consumption at a cost of $0.00) and elasticity of demand (i.e., α, the sensitivity of consumption as cost increases). Values of Q_0 and α in this task were positively skewed, so Q_0 and α values were log-transformed prior to data analyses.

Cigarette craving measure: A brief version of the Questionnaire of Smoking Urges (QSU-Brief; Tiffany & Drobes, 1991) was used to assess craving of smoking. Ten smoking-related items were rated by participants (e.g., “I would do almost anything for a cigarette right now”). Participants were asked to rate the extent to which they agree or disagree with each statement using a 5-point Likert scale (from 1-strongly disagree to 5-strongly agree). Total scores are calculated by combining the scores for all items, with higher total scores reflecting a higher state craving for cigarettes.

Statistical Analysis—Descriptive statistics, chi-square analysis, and one-way analysis of variance (ANOVA) were used to compare means and frequencies of sample characteristics among the three groups. For all groups, overall scores for event valence, salience, arousal, and vividness were determined by averaging the ratings for each of the seven user-generated events. One-way ANOVA analyses were used to compare ratings of valence, salience, arousal, and vividness scores among the three groups (i.e., EFT-health goal, EFT-general, and ERT-general). Moreover, to determine if valence, salience, and arousal scores were

significantly correlated with discounting, nonparametric Spearman correlations were run to assess the association between those scores and AUC of discounting.

One-way ANOVA was conducted to determine statistically significant differences between groups on levels of discounting (AUC). Separate ANOVAs were conducted to compare the intensity of demand (log[Q_0]), the elasticity of demand (log[α]), and cigarette craving (i.e., QSU-brief scores) among groups. When appropriate, post hoc comparisons were conducted using the Tukey pairwise correction. Partial Eta squared η_p^2 effect sizes were included, with values η_p^2= 0.01 indicative of a small effect size, η_p^2 = 0.06 indicative of a medium effect size, and η_p^2 = 0.14 indicative of a large effect size (Cohen, 1988). All the statistical analyses were conducted using SPSS 25.0 at a significance level of 0.05.

Results and Discussion

The demographic characteristics for participants were compared across the three groups using ANOVA and Chi-square and no group differences for any of the demographic measures were observed. Salience (p<.001) and arousal (p<.001) scores were significantly different between groups (Table 1). However, no significant correlations were found between discounting and scores of salience (r(189)= .091, p=.214), arousal (r(189)= .024, p=.741), valence (r(189)= −.135, p=.064), or vividness (r(189)= −.052, p=.475).

The ANOVA analyses indicated a significant main effect of group on AUC of discounting (F(2, 186) = 4.254; p=.016; η_p^2 =.044) with post hoc comparisons indicating significantly lower levels of discounting among participants in the EFT-health goal (M = .402, SD =.267, p=.033, η_p^2 =0.044) and the EFT-general (M = .406, SD =.250, p=.036, η_p^2 =0.050) groups compared to ERT-general control (M = .288, SD = .264; Figures 2 and 3). No significant difference was observed in AUC between EFT-health goal and EFT-general (p=.997). In addition, a significant main effect of group on intensity of demand (F(2, 127) = 8.782; p<.001; η_p^2 =.121), elasticity of demand (F(2, 126) = 4.533; p=.013; η_p^2 =.067), and cigarette craving (F(2, 184) = 8.411; p<.001; η_p^2 =.084) among the three groups was found. The post hoc analyses indicated significantly lower intensity of demand (M = 1.10, SD =.435, p=.001, η_p^2 =0.129), higher elasticity of demand (M = −1.88, SD =.756, p=.010, η_p^2 =0.032), and lower cigarette craving (M = 2.87, SD =.1.055, p<.001, η_p^2 =0.121) among the EFT-health goal group compared to ERT-general control (Figures 2 and 3). In addition, the post hoc analyses indicated a significantly lower intensity of demand among the EFT-health goal compared to the EFT-general group (M = 1.37, SD =.301, p=.002, η_p^2 =0.115). Interestingly, unlike EFT-health goal, no significant differences were observed between EFT-general and the control in intensity of demand (p= .946), elasticity of demand (p=.604), or cigarette craving (p=.199).

The first study examined the effects of EFT-general and EFT-health goal conditions on levels of discounting, cigarette craving, and valuation of cigarettes among smokers. Analyses showed that monetary discounting in smokers was significantly lower among both EFT-general and EFT-health goal compared to the control group. Indeed, EFT-health goal was associated significantly with lower cigarette craving and intensity of demand and higher elasticity of demand compared to the control group. In addition, EFT-health goal was associated significantly with lower intensity of demand compared to the EFT-general group.

Importantly, though EFT-general showed ordinally-lower demand and craving when compared to ERT-general control, the change in smokers' craving and valuation of cigarettes did not reach significance. These findings may be a result of the sample population not being adequately powered to detect the effect of EFT-general compared to the control group or possibly a result of including only heavy smokers in the current study compared to previous research (20 or more cigarettes daily vs. 10 or more cigarettes daily in past studies, respectively; Stein et al., 2018). Future research replicating the study with a larger sample may be necessary.

Adding a personal health goal to future thinking may amplify the effect of EFT and provide an additional source of motivation to produce the desired behavioral change, with discounting, craving, and valuation of reinforcers decreasing in functionally predictable ways. In line with this reasoning, previous research using fMRI data suggests that goal-related future thinking activates areas associated with prospection in the brain more than general events (D'Argembeau et al., 2010). Moreover, outcome simulations that prompt the respondent to imagine accomplishing a goal recruit brain areas that allow individuals to envision the effective consequences of achieving those goals (Gerlach, Spreng, Madore, & Schacter, 2014).

While Study 1 showed that combining a health goal with general EFT was associated significantly with less craving and demand for cigarettes, the role of future thinking in this combination is not entirely clear. In other words, could health-related ERT produce a similar effect? In addition, are these findings generalizable to other domains of health and their respective populations (e.g., obese or alcohol-dependent individuals, etc.)? To answer these questions, in Study 2 we included an additional, fourth group (i.e., health-related ERT) in which participants created episodic recent thinking events including health-related activities. In addition, in Study 2, we aimed to systematically replicate and extend the results of Study 1 by assessing the effect of EFT-health goal on discounting rates, fast food valuation, and fast food demand among obese individuals.

Study 2

Methodology

A total of 258 obese participants met eligibility qualifications and completed the study. Participants were randomly assigned to one of four conditions in a 2 × 2 factorial design with EFT/ERT as one factor and general/health goal as the second factor resulting in four groups: (1) EFT-health goal, (2) EFT-general, (3) ERT-health goal, and (4) ERT-general. Three participants failed the attention check questions (one from the EFT-health goal group and two from the ERT-general group) with the remaining participants included in the analyses (final N=255, EFT-health goal n=63, EFT-general n=61, ERT-health goal n=60, ERT-general n=71).

All procedures were identical to Study 1 (including the demographics questionnaire, episodic cue generation tasks, and DD tasks) with the following exceptions: Prior to EFT or ERT cue generation, participants selected their favorite fast food item from a provided list (Sze et al., 2017). Moreover, following completion of the DD task participants completed an

assessment of food craving and a food purchase task. The fast-food purchase task used in the current study was adopted and modified (used a purchase period of 24 hours) from the task used by (Sze et al., 2017).

Study Procedures and Measures—Participants completed a brief demographic questionnaire, selected their favorite fast food, generated the assigned events (i.e., EFT-health goal, EFT-general, ERT-health goal, or ERT-general), and completed an adjusting-amount discounting task (Du et al., 2002). After, participants completed an assessment of fast food craving and a fast-food purchase task which were presented in random order. We collected demographic data as outlined in Study 1. In addition, body mass index (BMI) was calculated using participants' self-reported height (in inches) and weight (in pounds).

Fast food selection: Participants were presented with a list of 14 popular, branded fast food items (e.g., Taco Bell tacos, Panera bagels, Krispy Kreme donuts; for the complete list see Sze et al., 2017) and prompted to select their preferred item from the list. Additionally, they were asked to rate how much they liked the selected food (from 1-not at all to 5-very much). The indicated food item was then included in the food purchasing task.

Episodic events generation: Participants in the EFT-health goal, EFT-general, and ERT-general groups completed the episodic cue generation tasks as outlined in Study 1. Participants in the ERT-health goal group were instructed to think about health-related activities associated with their past events (did not have to be related to losing weight but could be). To assist participants in making this connection, examples were provided describing positive health-related actions (e.g., "Earlier this morning, I was at work looking great in my new dress after losing some weight last month"). ERT-health goal participants were instructed to describe events which they had enjoyed in the previous three days (from "earlier this morning" to "three days ago"). All participants were asked to carefully describe events which were positive, vivid, and specific to the individual.

Adjusting-amount discounting task: Delay discounting data were collected in Study 2 as outlined in Study 1. Similarly, corresponding event cues were presented on the screen at each delay during the task. For the same reasons described in Study 1, we excluded participants in Study 2 whose delay discounting data did not meet the standardized criteria (Johnson & Bickel, 2008).

Fast food purchase task: The fast food purchase task implemented in the present study is a hypothetical purchasing task adapted and modified from the task detailed by Sze et al. (2017). Participants were prompted to indicate the number of single servings of their preferred fast food item that they would purchase to consume over the following 24-hour period (Sze et al., 2017 asked about the quantity one would purchase to consume over the following seven days) at twelve escalating price points per serving: $0.00, $0.12, $0.25, $0.50, $1.00, $2.00, $5.00, $10.00, $20.00, $40.00, $80.00, and $160.00. During the task, participants were asked to assume that: (1) food would be consumed in one 24-hour period; (2) no other access to this specific food would be allowed (but access to other foods was unrestricted); (3) the only available serving sizes were those detailed in each question; and (4) purchased food could not be given away or shared. At each increasing price point,

participants were presented with a randomly-selected textual episodic cue from their generated list and asked to vividly imagine the event while making their decisions.

Similar to Study 1, the purchase data were assessed for non-systematic purchasing using standard diagnostic criteria (Stein et al., 2015) prior to analysis, and demand data of those who violated the Stein et al. criteria were excluded from purchase task analysis but included in all other analyses (total excluded N=56, EFT-health goal n=15, EFT-general n=10, ERT-health goal n=17, ERT-general n=14). The frequency of non-systematic purchase data did not differ significantly by group (χ^2 (3, N=255) = 2.859, p=.414). A consort diagram displaying which specific purchasing criteria (Stein et al., 2015) were violated for those excluded from demand analysis from the four groups is shown in Figure 4.

Similar to Study 1, an estimate of demand curves was created by fitting purchases across the range of prices to the exponential demand curve equation (Koffarnus et al., 2015), and indices of demand such as intensity and elasticity were generated. Values of Q_0 and α in this task were positively skewed, so Q_0 and α values were log transformed prior to data analyses.

State Food Craving Questionnaire (FCQ-S): The State Food Craving Questionnaire, as developed by Cepeda-Benito, Gleaves, Williams, and Erath (2000), is a self-report inventory designed to examine craving as a psychological state in reaction to a specific set of conditions. The FCQ-S is a valid measure which has demonstrated high internal consistency (Cepeda-Benito, Fernandez, & Moreno, 2003; Cepeda-Benito, Gleaves, Williams, & Erath, 2000; Moreno, Rodríguez, Fernandez, Tamez, & Cepeda-Benito, 2008). The assessment includes fifteen statements that measure five dimensions of food craving, including intense desire to eat, the anticipation of positive reinforcement, the anticipation of relief from negative states and feelings, preoccupation with food and lack of control over eating, and feelings of hunger (Cepeda-Benito et al., 2000). Participants are asked to indicate the extent to which they agree with each statement using a 5-point Likert scale (from 1-strongly disagree to 5-strongly agree). Total scores are calculated by combining the scores for all items, with higher total scores reflecting a higher state craving for food.

Statistical Analysis—Descriptive statistics, chi-square, and one-way ANOVA analyses were used to compare means and distribution of sample characteristics within the four experimental groups (EFT-health goal, ERT-health goal, EFT-general, ERT-general). The discounting area under the curve (AUC) was examined using a two-way ANOVA including between-subjects main effects of episodic thinking (EFT and ERT) and orientation of the cues (health goal and general) of all seven delays. Separate two-way ANOVAs, including the aforementioned between-subjects main effects, were conducted for measures of intensity of food demand, the elasticity of food demand, and scores of food craving. When appropriate, post hoc comparisons were conducted using Tukey pairwise correction. Partial Eta squared η_p^2 effect sizes were included, with values ηp^2= 0.01 indicative of a small effect size, ηp^2 = 0.06 indicative of a medium effect size, and η_p^2 = 0.14 indicative of a large effect size (Cohen, 1988). All the statistical analyses were conducted using SPSS 25.0 at a significance level of 0.05.

Results and Discussion

The demographic characteristics for each group, with one-way ANOVA and chi-square results, are displayed in Table 2. The analysis did not indicate any differences between the groups for the demographic measures collected, food liking scores, or any of the cue characteristics ratings (i.e., scores of salience, arousal, valence, and vividness).

A two-way between-subjects ANOVA was conducted to compare the independent and interactive effects of EFT/ERT and general/health goal cues in the EFT-health goal, EFT-general, ERT-health goal, and ERT-general groups. There was a significant main effect of EFT on delay discounting, the intensity of demand, and fast food craving (Table 2). There was also a significant main effect of the health goal factor on the intensity of demand, the elasticity of demand, and fast food craving. None of the interactions of the factors were significant (Table 2).

Planned post hoc analysis indicated that, compared to general ERT, health goal EFT not only had higher AUC of discounting ($p<.001$, $\eta_p^2=.115$), but also significantly lower intensity of demand ($p<.000$, $\eta_p^2=.265$), higher elasticity of demand ($p=.044$, $\eta_p^2=.086$), and lower craving of fast food ($p=.004$, $\eta_p^2=.081$). In addition, participants in the EFT-health goal group showed significantly higher AUC of discounting ($p=.001$, $\eta_p^2=0.096$) and lower intensity of demand ($p=.005$, $\eta_p^2=0.143$) compared to the ERT-health goal group. Interestingly, compared to the EFT-health goal group, the EFT-general demonstrated significantly higher intensity of demand ($p<.001$, $\eta_p^2=.216$) and lower elasticity of demand ($p=.004$, $\eta_p^2=.115$; Figures 5 and 6).

Post hoc analysis indicated that EFT-general ($M=.407$, $SD=.272$) was significantly associated with higher AUC of discounting compared to ERT-general ($M=.239$, $SD=.200$, $p=.001$, $\eta_p^2=.110$) and ERT-health goal ($M=.252$, $SD=.214$, $p=.003$, $\eta_p^2=.091$; Figure 5). However, the EFT-general was not significantly different in AUC when compared to the EFT-health goal group ($M=.415$, $SD=.280$, $p=.998$). In addition, the EFT-general group was not significantly different in the intensity of demand ($p=.706$, $\eta_p^2=.013$), the elasticity of demand ($p=.935$, $\eta_p^2=.007$), or fast food craving ($p=.612$, $\eta_p^2=.016$) when compared to both ERT groups (Figures 5 and 6).

Consistent with Study 1, Study 2 reported that monetary discounting was significantly lower among both EFT-general and EFT-health goal compared to ERT-general and ERT-health goal. Adding a health-related component to recent thinking did not produce similar effects to adding it to future thinking when compared to controls. Future thinking in the current results was necessary for decreasing the discounting rates. Stein et al. (2018) and Rung and Madden (2019) indicated that EFT decreases rates of discounting (i.e., broadens the temporal window over which reinforcers are integrated) independent of the “good subject” effect (Orne, 1962) in which participant’ decisions and responses might be confounded and guided by their expectancies about the purpose of the study. It should be noted note that the temporal window of integration measured by delay discounting represents the temporal distance over which one consider and integrate future outcomes into present decisions and behaviors and does not refer to how far one can think or imagine in the future (i.e., the temporal horizon) that might not be as affected by EFT (Rung & Madden, 2019).

Similar to Study 1, Study 2 showed that combining a health goal with general EFT was associated significantly with less craving and demand for cigarettes compared to the control. In addition, EFT-general did not significantly change intensity and elasticity of demand for cigarettes or fast food. This finding is surprising given earlier findings of reduction in cigarette self-administration (Stein et al., 2016), cigarette purchasing (Stein et al., 2018), food purchasing (Hollis-Hansen et al., 2018; Sze et al., 2017) and caloric intake in obese women (Daniel et al., 2013b) and children (Daniel et al., 2015) in the EFT-general group compared to the ERT groups. These mixed findings could be attributed to the fact that the current study is not powered to detect a difference or attributed to the differences between the hypothetical purchase tasks used in the current investigation and the ones used in the previously mentioned studies (except the cigarette purchase task used by Stein et al., 2018). Future research comparing the effect of EFT on various real and hypothetical demand and purchasing tasks (e.g., Stein et al., 2016; Hollis-Hansen et al., 2018; Sze et al., 2017; Daniel et al., 2013b; Daniel et al., 2015) might be beneficial. Moreover, Study 2 extended the generalizability of findings from Study 1 to include obese individuals. In the next section we discuss findings from both studies in more details.

General Discussion

In this investigation, using two separate studies, we examined the effects of an Episodic Future Thinking intervention with and without a health goal component on rates of monetary discounting, demand, and craving for cigarettes and fast food among cigarette smokers and obese individuals, respectively. In both studies, Episodic Future Thinking with and without health goal component was significantly associated with lower monetary discounting compared to the control group(s). Moreover, the Episodic Future Thinking including a health goal component was significantly associated with lower intensity of demand compared to Episodic Future Thinking without health goal and the control groups, and was associated significantly with lower craving and higher elasticity of demand compared to the control group(s). In addition, participants in Study 2 demonstrated a higher elasticity of demand among the Episodic Future Thinking with a health goal compared to the Episodic Future Thinking without a health goal. Below, we discuss these findings in more detail.

The current findings reaffirm previous research indicating that EFT reduces discounting across various populations (Benoit et al., 2011; Daniel et al., 2015, 2013a, 2013b; Lin & Epstein, 2014; Peters & Büchel, 2010; Rung & Madden, 2019; Stein et al., 2018). In the present study, tailoring the EFT cues to be specific to health goals did not amplify the effect on reducing monetary discounting compared to general EFT. The current findings, though appearing contradictory to previous research reports indicating a greater effect of financial-goal EFT on monetary DD compared to general EFT (O'Donnell et al., 2017), may actually address the generalizability of their findings. In other words, our findings suggest that the effect of goal-based EFT could generalize to non-financial goals, such that individuals with substance use disorder and/or obesity whose future goals relate to improvements in health (e.g., quitting smoking or losing weight) would benefit from such health-goal-oriented EFT. Employing health goals to motivate behavioral change may be particularly relevant for individuals faced with the choice between consuming an addictive substance now to satisfy the desire for an immediate reward versus not consuming it to attain a desired future health

scenario, such as quitting smoking, avoiding diseases, or losing weight. To increase our understanding of the association between the health-goal EFT and valuation of unhealthy reinforcers, future studies testing the effect of health-goal EFT on the discounting of different types of unhealthy commodities (e.g., discounting of substances and/or health) and investigating the effect of health-goal EFT on valuation of multiple unhealthy substances/behaviors among the same population (e.g., drinkers who smoke) would be beneficial.

The present finding of no effect of general EFT on cigarettes craving is consistent with those reported by Stein et al. (2018) who indicated no significant effect of EFT on cigarette craving, as measured by the QSU-Brief. In addition, the current investigation did not observe a significant effect of EFT-general on fast food craving. Similar to the first study to assess the effect of EFT on fast food craving, future research replicating the current findings by assessing the effect of EFT on several craving measures among different populations might be warranted to reach a firm conclusion and increase our understanding of the association between future thinking and craving. In addition, our results are consistent with the hypothesis that the effects of EFT are driven by a change in the temporal window over which the value of reinforcers are integrated, rather than by demand characteristics (Stein et al., 2018) or a change in time perspective (how far one can think into the future) more generally (Rung and Madden, 2019).

The current findings of reduced craving and valuation of addictive reinforcers (e.g., cigarettes and fast food) among the health-goal EFT participants suggests a potential domain-specific effect of adding a health goal to EFT that may decrease craving and valuation for a particular unhealthy reinforcer if those reinforcers hinder attainment of the desired goal. In support of this potential explanation, previous data suggest that imagining accomplishing a goal by simulating its outcomes recruits brain areas that permit individuals to envision the consequences of achieving that goal (Gerlach et al., 2014). In addition, including a desired personal health improvement or goal in imagined future scenarios may increase connectedness to the future, potentially allowing the respondent to develop a greater motivation to reach that goal and therefore value unhealthy reinforcers less and the future more. For example, if a person is looking forward to losing weight for a beach trip in the summer, the choice of fast food, while presently attractive, would negatively impact his or her ability to accomplish the goal of losing weight. Hence, the motivations to reduce consumption of unhealthy food may become more cognitively salient when cues include losing weight or improving physique as a future health goal that the person is looking forward to attaining. Perhaps, the more that one contemplates the positive consequences of achieving future goals (e.g., imagining having glowing skin and a healthier look), the greater the motivation to fulfill those goals. People who have difficulty resisting the immediate gratification of consuming an unhealthy substance (e.g., fast food, cigarettes) may benefit from imagining a future in which they have accomplished their health goals and can then appreciate the results. EFT structured around health goals allows an individual to fully consider both the potential benefits of overcoming the urge for immediate pleasure and the value of future rewards. Amplifying future thinking by including a health goal may promote healthy decisions and be a mechanism by which EFT can result in positive behavior changes. The development of multi-component treatments that incorporate a health-goal EFT component may amplify the effect in reducing the consumption of unhealthy

reinforcers. For example, the effect of proximally oriented interventions such as contingency management can be diminished or lost when the contingences provided are terminated (Benishek et. Al., 2014). However, if such treatments were combined with interventions that have the ability to not only increase the valuation of immediate alternative contingences but also of extended positive outcomes of abstinence (e.g., EFT- health goal), the treatment outcomes would perhaps be extended and improved. Future clinical research may examine using Episodic Future Thinking structured around health goals as an adjuvant to other treatments, like contingency management.

Our investigation has some potential limitations. In both studies, participants were mostly non-Hispanic, with a high proportion of the Caucasian population. Future research with broader populations might be necessary to generalize the current results. The use of mTurk limited our data to online data only. However, online data collection has been previously validated in studies which reported similar results to those collected in the laboratory setting (Athamneh, Stein, & Bickel, 2017; Birnbaum, 2000; Buhrmester, Kwang, & Gosling, 2011; Paolacci, Chandler, & Ipeirotis, 2010; Suri & Watts, 2011). In addition, mTurk studies have replicated the effect of episodic future thinking (Sze et al., 2017) on discounting-related phenomena associated with cigarette smoking and alcohol use disorder (Athamneh et al., 2017; Jarmolowicz, Bickel, Carter, Franck, & Mueller, 2012; P. S. Johnson, Herrmann, & Johnson, 2015; VanderBroek, Acker, Palmer, de Wit, & MacKillop, 2016). In the current investigation, all discounting and purchasing choices were purely hypothetical. However, findings from hypothetical discounting and purchasing tasks are similar to those using real or potentially-real rewards (Johnson & Bickel, 2002; Wilson, Franck, Koffarnus, & Bickel, 2016). Regardless of these limitations, we believe the present study adds to the literature and contributes new knowledge that may help to optimize the effect of EFT as a potential component of future behavioral interventions which aim to prevent and/or treat addiction and obesity.

Conclusion

Health-goal EFT was not more effective than general EFT in reducing monetary discounting. However, the addition of a health goal to general EFT was associated with significantly higher effect on intensity and elasticity of demand for cigarettes and fast food compared to general EFT. These findings suggest that the amplification of future thinking through the inclusion of a health goal may promote healthy decisions and result in positive behavior changes.

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None of the authors have any conflicts of interest to declare. Portions of data from the current manuscript were presented as a poster in October, 2019 at the 7th Annual Conference of the Vermont Center on Behavior and Health, Burlington, VT and has been accepted as a poster presentation for the annual conference for the Society for

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Public Significance Statement

This investigation's findings suggest that while episodic future thinking including a health goal is not more effective in reducing one's discounting of the future compared to general episodic future thinking (i.e., without a health goal), the addition of a health goal to episodic future thinking was significantly associated with higher effect on valuation for cigarettes and fast food among smokers and obese individuals, respectively. These findings suggest that the amplification of future thinking through the inclusion of a health goal may promote healthy decisions and result in positive behavior changes.

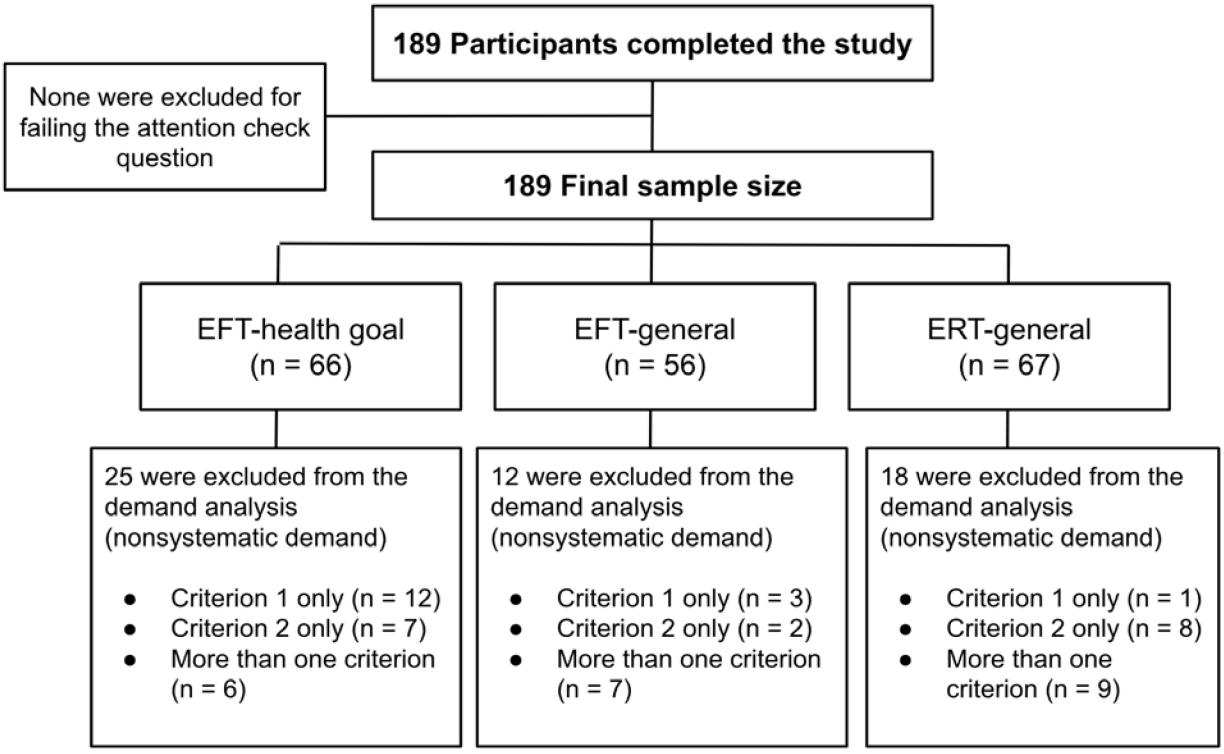

Figure 1.
A consort diagram of **Study 1** showing reasons for exclusion from the demand analyses (Stein et al., 2015)

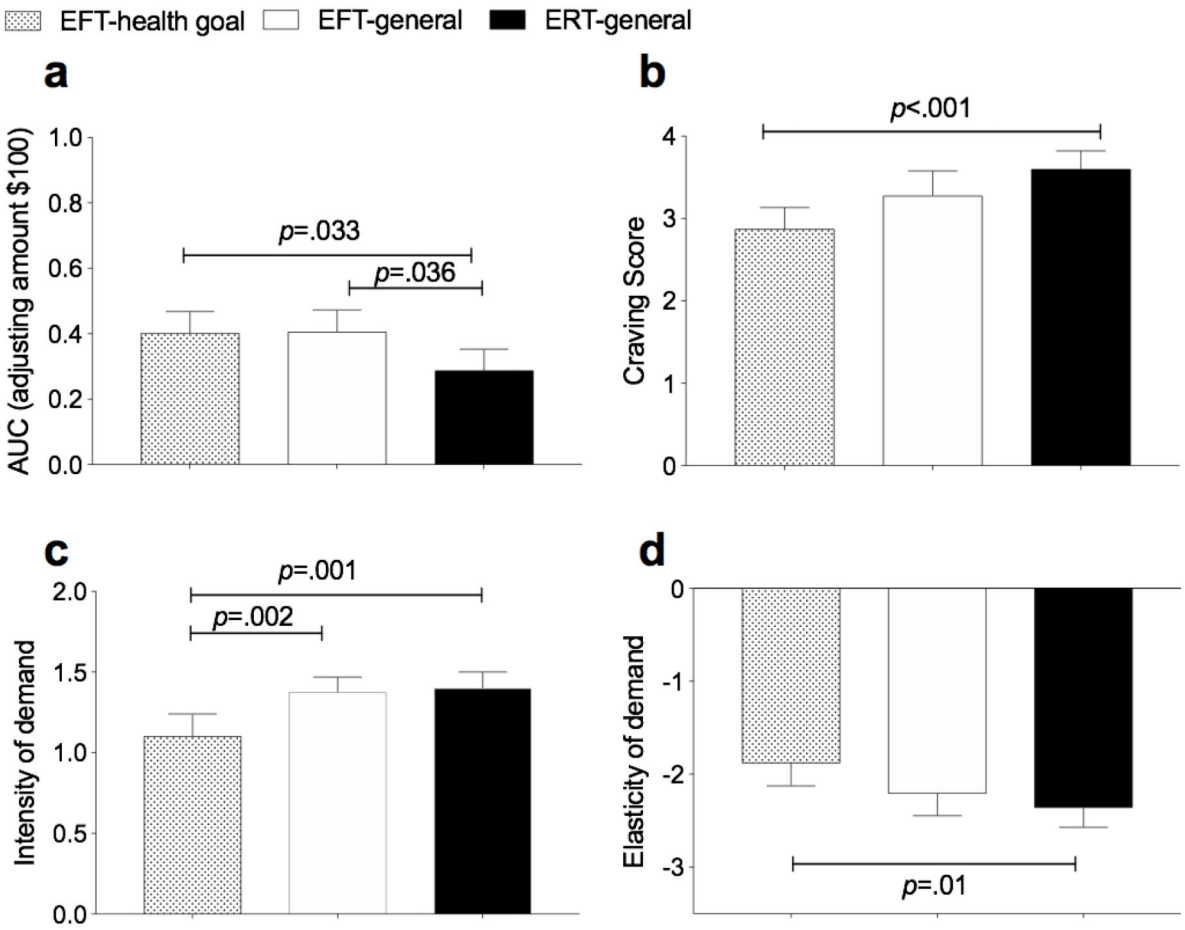

Figure 2.

A post hoc comparison from Study 1 of (a) AUC, (b) craving score, and (c) intensity and (d) elasticity of demand between EFT-health goal, EFT-general, and ERT-general.

Error bars represent 95% confidence intervals.

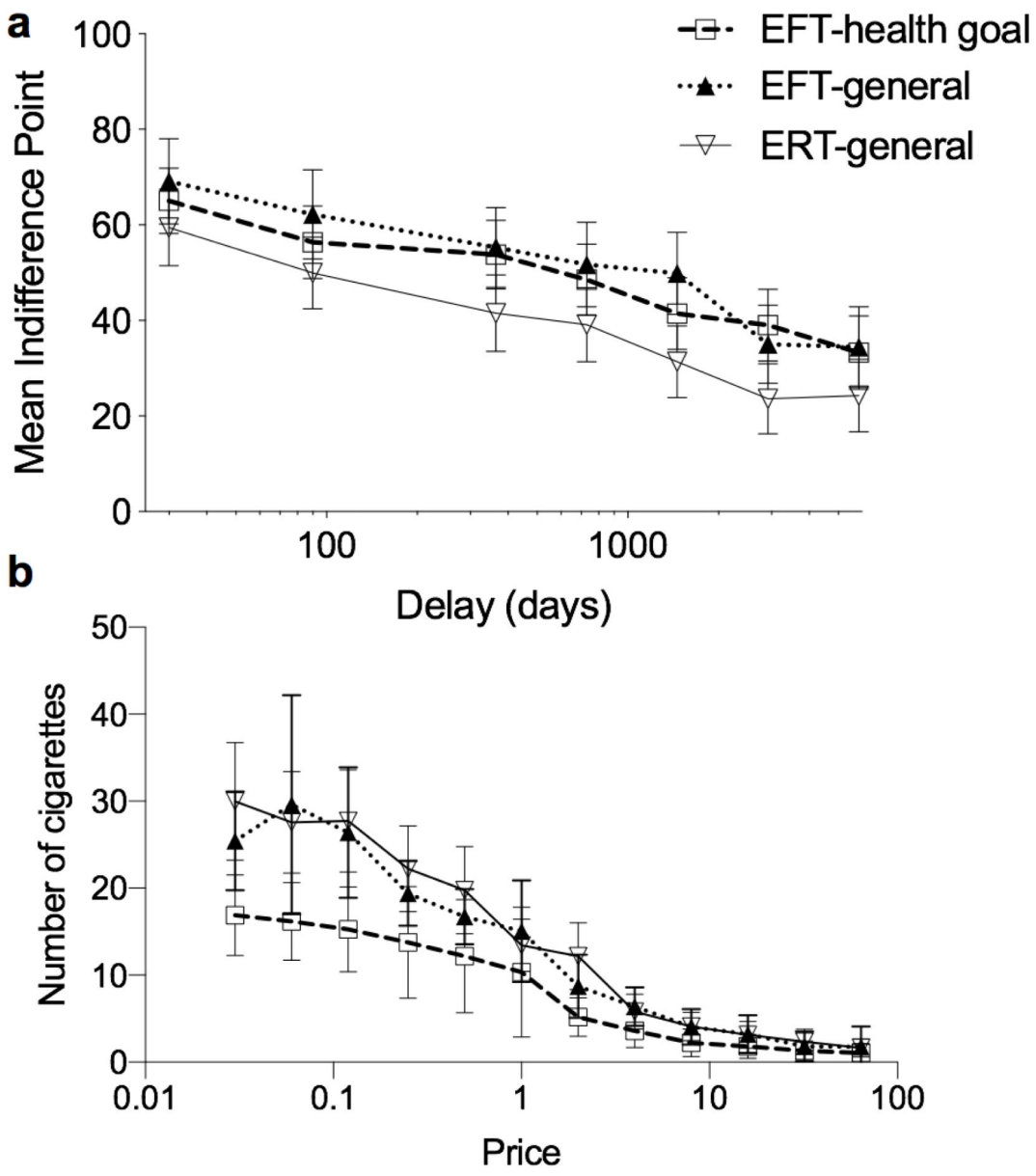

Figure 3.

(a) The mean indifference points of $100; and (b) the demand points for the three groups in Study 1

The x-axis in figure (a) is on a log scale

Error bars represent 95% confidence intervals.

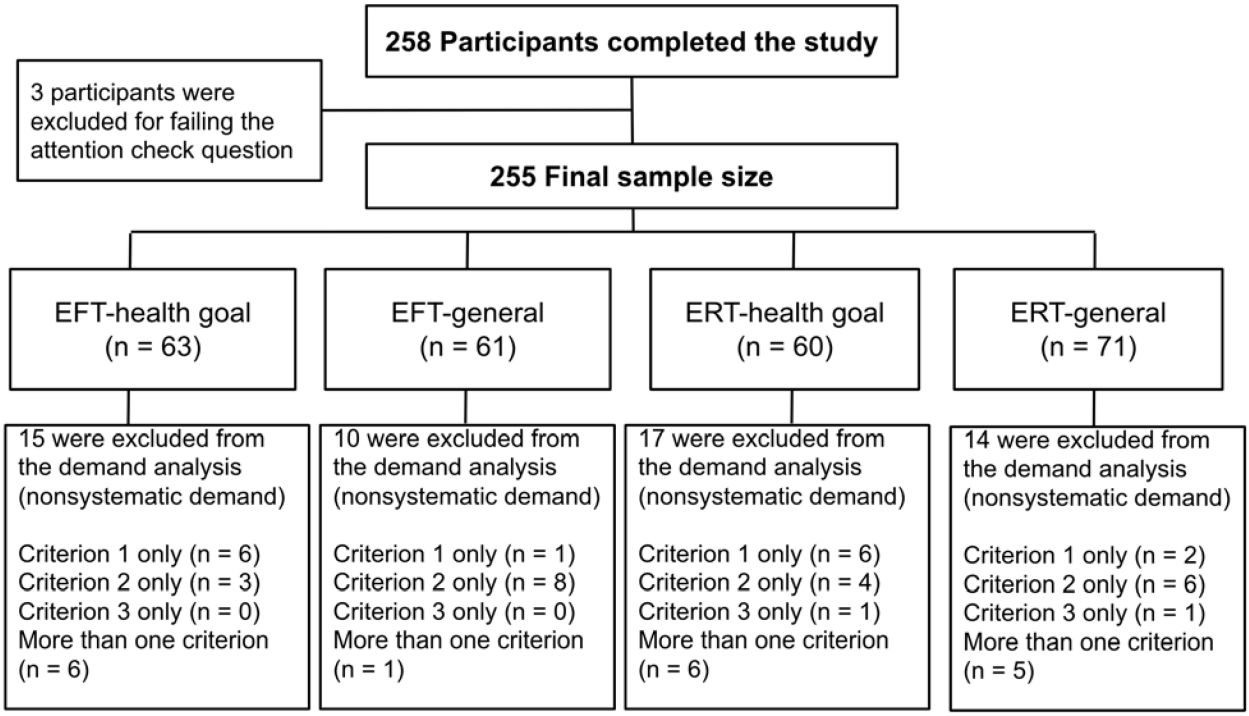

Figure 4.

A consort diagram of Study 2 showing reasons for exclusion from the whole study and from demand analyses (Stein et al., 2015)

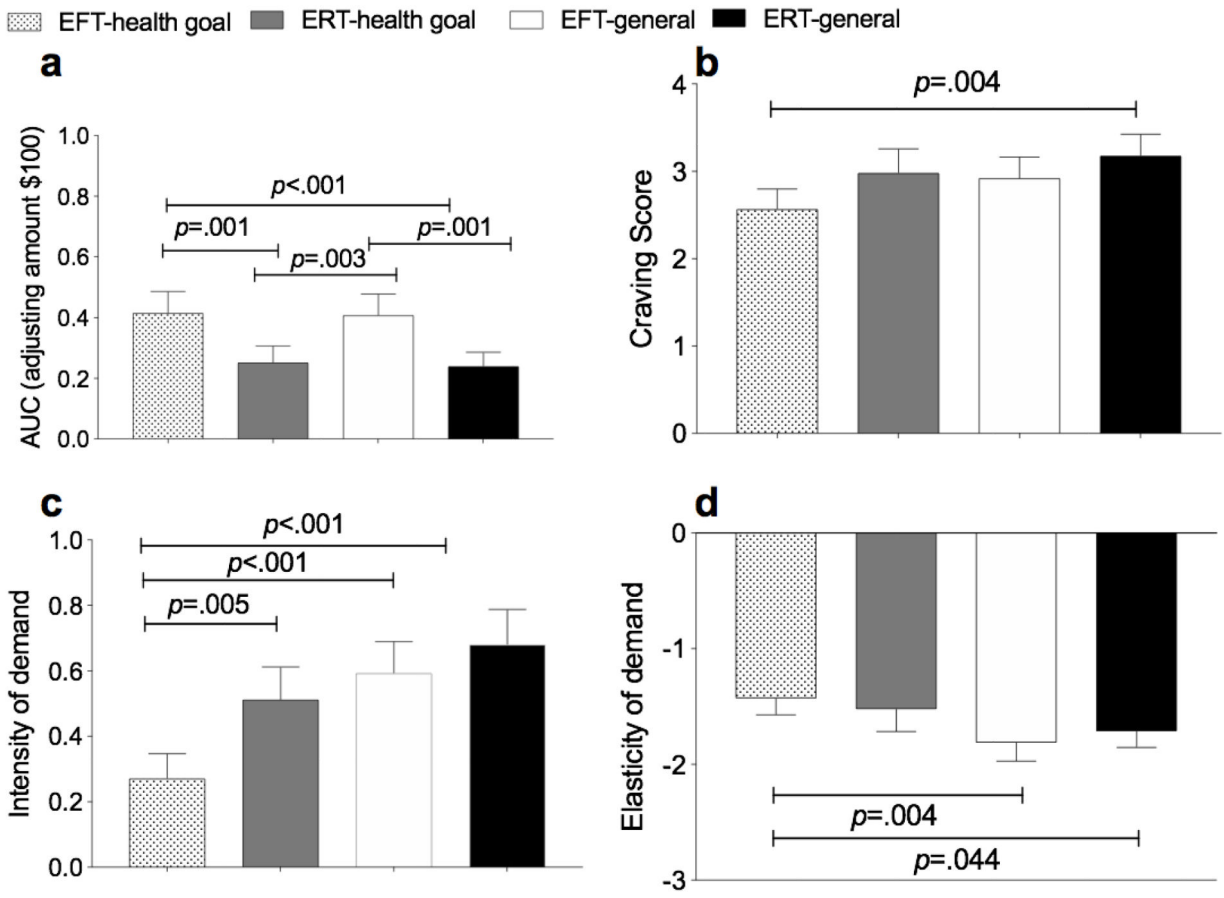

Figure 5.

A post hoc comparison from Study 2 of (a) AUC, (b) craving score, (c) intensity, and (d) elasticity of demand between EFT-health goal, EFT-general, ERT-health goal, and ERT-general.

Error bars represent 95% confidence intervals.

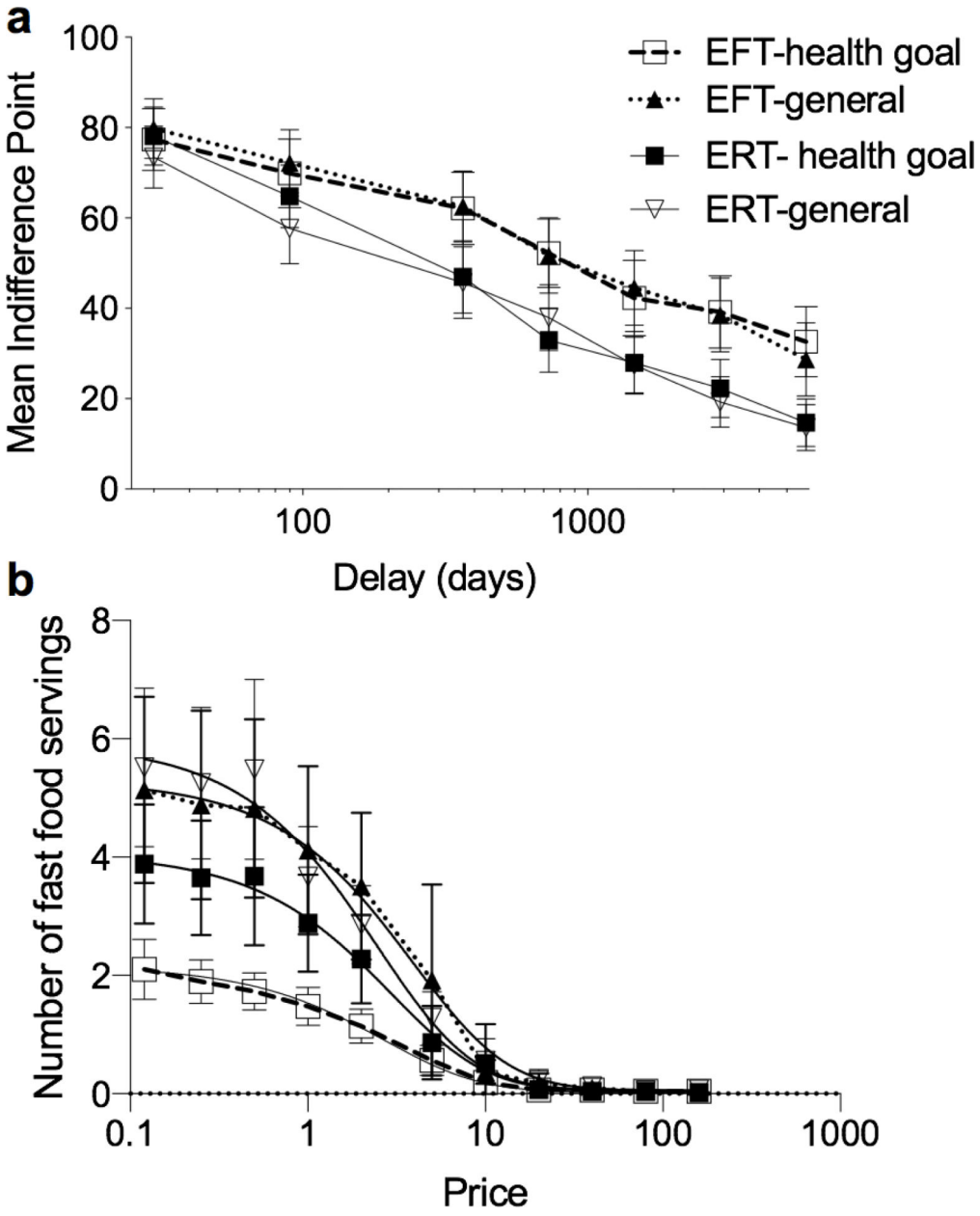

Figure 6.

(a) The mean indifference points of $100; and (b) the demand points for the four groups in Study 2

The x-axis in figure (a) is on a log scale

Error bars represent 95% confidence intervals.

Table 1.

Sample Characteristics by Group from Study 1 (N=189)

Characteristics	Frequency (% within group)				
	EFT-health goal (n=66)	**EFT-general (n=56)**	**ERT-general (n=67)**	**Pearson Chi-Square**	**P value**
Cigarettes Smoked Daily *Mean (SD)*	23.0 (9.34)	24.6 (11.58)	27.3 (15.48)		.136
Age *Mean (SD)*	34.8 (9.15)	34.9 (9.62)	34.4 (8.56)		.941
Female	30 (45.5)	19 (33.9)	21 (31.3)	3.169	.205
White	52 (78.8)	46 (82.1)	57 (85.1)	12.907	.640
Non-Hispanic or Latino	61 (92.4)	52 (94.5)[a]	55 (83.3)[a]	5.970	.087
Education level				6.852	.560
Some college/less	23 (34.8)	24 (42.9)	23 (34.3)		
4-year degree/higher	43 (65.2)	32 (57.1)	44 (65.7)		
Income	[a]			17.678	.748
$0 – $29,999	8 (12.3)	10 (17.9)	10 (14.9)		
$30,000 – $49,999	15 (23.1)	12 (21.4)	20 (29.9)		
$50,000 – $69,999	23 (35.4)	15 (26.8)	16 (23.9)		
$70,000 and greater	19 (29.2)	19 (33.9)	21 (31.3)		
Cue characteristics *Mean (SD)*					
Valence	4.32 (.59)	4.34 (.56)	4.1 (.59)		.270
Salience	4.20 (.54)**	4.26 (.53)**	3.69 (.90)		<.001
Arousal	4.23 (.52)**	4.38 (.51)**	3.77 (.74)		<.001
Vividness	4.33 (.55)	4.43 (.51)	4.22 (.66)		.133

[a] one participant chose not to report

** p<.001 compared to control

Table 2.

Sample Characteristics by Group from Study 2 (N=255)

	Frequency (% within group)				
Characteristics	**Health goal EFT n=63**	**Health goal ERT n=60**	**EFT-general n=61**	**ERT-general n=71**	**P value**
BMI *Mean (SD)*	39.2 (14.63)	36.4 (6.94)	35.7 (4.86)	37.5 (8.38)	.054
Age *Mean (SD)*	37.5 (11.92)	36.1 (10.38)	37.2 (10.33)	35.8 (11.61)	.985
Female	39 (61.9)	37 (61.7)	39 (65.0)[a]	36 (50.7)	.348
White	53 (84.1)	51 (85.0)	48 (80.0)[a]	54 (76.1)	.532
Non-Hispanic or Latino	59 (93.6)	57 (95.0)	55 (93.2)[aa]	64 (91.4)[a]	.879
Education level					.713
HS diploma/equiv.	5 (7.9)	6 (10.0)	4 (6.6)	4 (5.6)	
Some college/2-yr deg.	21 (33.3)	25 (41.7)	27 (44.3)	24 (33.8)	
4-yr deg./higher	36 (57.1)	29 (48.3)	30 (49.2)	43 (60.6)	
Income					.432
$0 – $29,999	13 (20.6)	16 (26.7)	12 (19.7)	20 (28.2)	
$30,000 – $69,999	33 (52.4)	29 (48.3)	31 (50.8)	25 (35.2)	
$70,000 and greater	17 (27.0)	15 (25.0)	18 (29.5)	26 (36.6)	
Cue characteristics *Mean (SD)*					
Valence	4.29 (.66)	4.31(61)	4.27 (.63)	4.31 (.53)	.985
Salience	3.85 (.96)	3.99 (.82)	3.64 (1.04)	3.76 (1.02)	.240
Arousal	3.87 (.84)	3.97 (.72)	3.70 (.90)	3.72 (.96)	.258
Vividness	4.39 (.67)	4.43 (.64)	4.21 (.81)	4.29 (.61)	.261

HS: High School

[a]One participant chose not to report

[aa]Two participants chose not to report

Table 3.

Two-Way Analysis of Variance of Discounting AUC, Demand Measures, and Fast Food Craving by Episodic Thinking and Health Goal (Study 2)

Variable	Source	*df*	*MS*	*F*	*p*	η_p^2
Discounting Rate (AUC)	Episodic Thinking	1	1.748	29.528	<.001	.105
	Health Goal	1	.007	.113	.737	<.001
	Factors Interaction	1	.000	.007	.932	<.001
	Total	255				
Intensity of Demand (log[Q_0])	Episodic Thinking	1	1.327	11.361	.001	.055
	Health Goal	1	2.949	25.246	<.001	.115
	Factors Interaction	1	.288	2.465	.118	.012
	Total	199				
Elasticity of Demand (log[α])	Episodic Thinking	1	.000	.001	.976	.000
	Health Goal	1	4.084	13.408	<.001	.064
	Factors Interaction	1	.436	1.432	.233	.007
	Total	199				
Fast Food Craving	Episodic Thinking	1	6.843	6.825	.010	.026
	Health Goal	1	4.518	4.506	.035	.018
	Factors Interaction	1	.341	.340	.560	.001
	Total	255				

Note:

MS = Mean squares

ηp^2= partial η^2= effect size