HHS Public Access

Author manuscript

*Eat Behav*. Author manuscript; available in PMC 2019 May 07.

Published in final edited form as:

*Eat Behav*. 2015 August ; 18: 20–24. doi:10.1016/j.eatbeh.2015.03.006.

# Episodic Future Thinking reduces delay discounting and energy intake in children

**Tinuke Oluyomi Daniel**[1,2], **Michele Said**[1], **Christina M. Stanton**[1], and **Leonard H. Epstein**[1,2]

[1]Department of Pediatrics, University at Buffalo School of Medicine and Biomedical Sciences

[2]Department of Community Health and Health Behaviors, University at Buffalo School of Public Health and Health Professions

## Abstract

Discounting of larger future rewards in favor of smaller immediate rewards is known as delay discounting. High delay discounting or a bias towards immediate gratification impedes self-regulation and is associated with maladaptive eating behaviors. Children in general show greater delay discounting than adults. Obese children in particular, have greater difficulty delaying gratification for edible rewards. Episodic future thinking (EFT) which is mental self-projection to pre-experience future events reduces delay discounting and reduces energy intake in overweight/obese adults. However, these EFT effects have not been examined in children. We evaluated the effects of EFT versus control episodic recent thinking (ERT) on delay discounting and *ad libitum* energy intake while thinking about episodic cues in 42 overweight/obese 9 to 14 year olds. Results showed EFT led to less delay discounting and lowered energy intake, and EFT had the greatest effect on reducing energy intake in children with a higher desire to restrict food intake. This suggests EFT may be useful in pediatric obesity treatment programs to help children regulate energy intake.

### Keywords

reducing delay discounting; reducing energy intake; obesity; episodic future thinking

Obesity is caused by energy intake in excess of energy expenditure (Hill, Melanson, & Wyatt, 2000) and is associated with chronic conditions such as cardiovascular disease, stroke

Correspondence and Reprint Requests: Correspondence concerning this article should be addressed to Leonard H. Epstein, Ph.D., Department of Pediatrics, School of Medicine and Biomedical Sciences, University at Buffalo, Farber Hall, Room G56, 3435 Main Street, Building #26, Buffalo, New York 14214-3000; phone (716) 829-3400; fax: (716) 829-3993; LHENET@acsu.buffalo.edu.

**Author Disclosures**: **Contributors**: Tinuke Oluyomi Daniel designed the study and protocol in collaboration with Dr. Epstein, with input from Michele Said and Christina Stanton. Tinuke Oluyomi Daniel, Michele Said and Christina Stanton implemented the study and collected the data. Tinuke Oluyomi Daniel conducted the statistical analysis under Dr. Epstein's supervision, with assistance from Michele Said. Tinuke Oluyomi Daniel wrote the manuscript with critical revisions from Dr. Epstein, and all authors contributed to and have approved the final manuscript.

**Conflict of Interest**: Dr. Epstein is a consultant and has equity in Kurbo Health. All other authors declare that they have no conflicts of interest.

and type-2 diabetes (Björntorp, 1990; Larson, Neumark-Sztainer, Laska, & Story, 2011). Despite the well-publicized adverse impact of obesity on health (Winter & Wuppermann, 2014), many individuals often over-indulge in unhealthy and high energy-dense foods. These individuals may prefer the immediate gratification of high energy-dense foods, instead of avoiding these foods for future health. This discounting of larger future rewards in favor of smaller immediate rewards is known as delay discounting and greater discounting occurs with increasing temporal distance between the immediate and delayed rewards (Bickel & Marsch, 2001). High delay discounting is cross-sectionally (Davis, Patte, Curtis, & Reid, 2010; Weller, Cook, Avsar, & Cox, 2008) and prospectively (Seeyave et al., 2009) related to obesity, and predicts greater consumption of high energy-dense ready-to-eat and away-from-home foods in obese women (Appelhans et al., 2012). Individuals with a high motivation to eat and high in delay discounting are more obese (Epstein et al., 2014) and have greater calorie consumption in *ad libitum* eating sessions (Appelhans et al., 2011; Rollins, Dearing, & Epstein, 2010).

A bias towards immediate gratification may present an even greater barrier to healthy eating for children compared to adults. Children in general show greater delay discounting than adults (Green, Fry, & Myerson, 1994; Steinberg et al., 2009). Obese children in particular, have greater difficulty delaying gratification for edible rewards (Bonato & Boland, 1983), and they find food more reinforcing than their leaner peers (Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008). Unfortunately, obese children that want to restrict calorie intake to reduce body weight have to delay gratification for food in order to lose weight. A bias towards immediate gratification can be an impediment to their ability to self-regulate food intake for future health and research shows that an immediate bias predicts diminished success with weight loss in obesity treatment (Best et al., 2012). Thus, techniques that reduce delay discounting or improve the ability to resist immediate gratification may reduce energy intake and improve weight loss.

One technique that reduces the bias towards immediate gratification is vividly imagining the future during decision-making using episodic future thinking (Daniel, Stanton, & Epstein, 2013a; Peters & Büchel, 2010). Episodic future thinking (EFT) is a type of prospective thinking that involves mental self-projection to pre-experience future events (Atance & O'Neill, 2001). EFT emerges between the ages of 3 to 5 years (Atance, 2008). It engages the episodic memory network and uses autobiographical details to mentally simulate the future (Atance & O'Neill, 2001; Schacter, Addis, & Buckner, 2008). EFT is thought to increase the value of delayed outcomes during decision making (Benoit, Gilbert, & Burgess, 2011) and steer individuals towards choices with long term benefits (Boyer, 2008). Additionally, we have demonstrated that EFT reduces delay discounting and *ad libitum* energy intake during a tempting food situation in overweight/obese adults (Daniel et al., 2013a; Daniel, Stanton, & Epstein, 2013b). While EFT ability emerges between 3 to 5 years of age (Atance & O'Neill, 2005), little is known about effects of EFT in children.

The aim of this study was to investigate the impact of EFT compared to control episodic recent thinking (ERT) on delay discounting and energy intake in children aged 9 to 14 years old. Our goal was to obtain data which will help to address the research gaps on EFT's effect in children. We chose to study children aged 9 to 14 years because studies on developmental

differences on delay discounting tasks typically examine children 9 years and above (Banich et al., 2013; Green et al., 1994; Steinberg et al., 2009). Similar to our previous study on EFT's effect on energy intake in adults, (Daniel et al., 2013b), we developed the *ad libitum* eating task in this study to maximize this as a tempting eating situation for an overweight/obese child.

We studied children who varied in their desire to restrict energy intake for weight loss (i.e. varied in dietary restraint) (Braet & Van Strien, 1997; Wardle, Guthrie, Sanderson, & Rapoport, 2001) to test individual differences that influence responsiveness to EFT's effect on energy intake. We expect that children low in dietary restraint will be the least responsive to EFT's effect and those high in dietary restraint will be most responsive to EFT and consume less food. For an obese child who is not motivated to restrict calorie intake for health, resisting immediate gratification may be inconsequential and an *ad libitum* eating situation could be an opportunity to indulge.

## 1. Methods

### 1.1. Participants

We studied 42 overweight/obese 9 -14 year-old children (Body Mass Index (BMI) ≥ 85$^{th}$ percentile for children of the same age and sex, mean BMI percentile + standard deviation = 93.91 + 3.18). Parents of potential participants were recruited through a laboratory database, flyers posted around the University at Buffalo campus, community settings and web-based advertisements. Parents provided information about their children (e.g. height, weight, age and sex) through telephone or web-based screening which was used to determine if their child met inclusion criteria. Parents also reported whether their child currently had any diagnosed psychological conditions (e.g. depression), was receiving psychological treatment or had any dietary restrictions to study foods. Children with psychopathology or dietary restrictions to study foods were excluded. Fifty percent of participants were females and seventeen percent were non-Caucasian. The sample size was determined based on the effect sizes from our previous study on EFT's impact on delay discounting (Cohen's $d = 1.51$) and energy intake (Cohen's $d = 1.09$). Based on these effect sizes, power at .80 and alpha at .05, we needed at least 17 participants per group. This study was approved by the Social and Behavioral Sciences IRB at the University at Buffalo.

### 1.2 Experimental Design and Procedures

Participants attended a 2 hour session, in which they engaged in EFT or control recent episodic thinking (ERT) during a delay discounting task, and then completed an *ad libitum* eating task. As research suggests that consuming sugar prior to a delay discounting task influences delay discounting rates (Wang & Dvorak, 2010), we chose not to counterbalance the order of the delay discounting and *ad libitum* eating task. Dietary restraint was assessed using the child version of the Dutch Eating Behaviors Questionnaire (van Strien & Oosterveld, 2008) prior to experimental tasks. At the end of the session, participants had their height and weight measured, were debriefed and mailed a $25 compensation check.

**1.2.1. Episodic Future Thinking Task—**We used a similar procedure as in our previous EFT studies (Daniel et al., 2013a, 2013b). Participants listed positive future events corresponding to the time periods in the delay discounting task (1 day, 2 days, 1 week, 2 weeks, 1 month, and 6 months). Participants rated the valence, salience, arousal, and vividness of autobiographical details of each event on Likert scales (1 for very low and 5 for very high). Since reductions in discounting occurred at higher levels of episodic imagery (Peters & Büchel, 2010), only events with the highest vividness ratings were used during the delay discounting task and *ad libitum* eating task. Once the most vivid events were identified, participants were audio recorded saying these event cues e.g. “In 6 months, I will be celebrating my birthday”. The audio recordings were used as episodic-thinking cues during the *ad libitum* eating task.

**1.2.2. Control Episodic Recent Thinking (ERT) Task—**The ERT task procedure was similar in every way to the EFT task except that instead of generating personal future events, participants recalled personal events they enjoyed that occurred within the last 24 hours. In this way, participants were engaged in imagery of personal and recently experienced events, rather than pre-experiencing future events. As with the EFT group, only recent events with the highest vividness ratings were used as episodic thinking cues during the delay discounting task and *ad libitum* eating task for the ERT group. Once the most vivid events were identified, participants were audio recorded saying these event cues and the audio recordings were used as episodic-thinking cues during the *ad libitum* eating task.

**1.2.3. Delay Discounting Task—**Discounting of hypothetical $50 reward was assessed at delays of 1 day, 2 days, 1 week, 2 weeks, 1 month and 6 months. Participants chose either the larger reward, available at a delay, or the smaller reward, available immediately, adjusted in 26 steps, 26 choices between various combinations of immediate and delayed rewards (Rollins, Dearing, & Epstein, 2010). Prior to each trial, EFT participants were instructed to think about vivid future events corresponding to the delayed time period (Peters & Büchel, 2010), whereas control participants thought about vivid recent events. Indifference points (delays at which participants were equally likely to choose either immediate or delayed rewards) (Dixon, Marley, & Jacobs, 2003) were calculated to compute area-under-the-indifference-curve values (Myerson, Green, & Warusawitharana, 2001). As a manipulation check, participants were asked to rate how much they thought about their episodic events during the delay discounting task using a Likert scale anchored by 1= not at all to 5 = very much.

**1.2.4. Ad Libitum Eating Task—**As in our previous EFT study (Daniel et al., 2013b), we used a two-phase taste test and incorporated three elements to simulate a tempting food situation for children. First, the taste test was comprised of a variety of sweets and cookies: Skittles, Strawberry Twizzlers, Gummy bears, Reese's Peanut-butter cups, Hershey's Chocolate bar, and Iced Animal Cookies (see Appendix). Second, sessions were scheduled in between meals (at least 90 minutes after a full meal and before their next meal). To make participants aware that this was a between-meal snack, before they started the taste test participants were asked 1) the time of their last meal and 2) the time of their next meal after the session. Third, in the first phase of the eating task, participants rated the sensory appeal

of study foods without tasting them for 5 minutes, to increase food craving and temptation to eat (Fedoroff, Polivy, & Herman, 1997, 2003). Thus, the timing of the session, sensory pre-exposure, and the type of food presented simulated elements of a tempting eating situation that might trigger overeating and difficulty delaying gratification for overweight/obese children.

In the second phase of the task, unlimited access to the foods was provided for 15 minutes and participants provided ratings of taste and food texture. We presented from 1275.8 to 1352.3 calories with the option of extra portions (up to another 1352.3 calories). To cue episodic thinking, we played the audio recordings of participants' reports of vivid future events to the EFT group. The ERT group was played audio recordings of participants' reports of vivid recent events. Foods were weighed before and after the task using an electronic scale with 0.01g sensitivity (Denver Instrument XP-300, Denver Instrument Company, Avada, Colorado). Total energy intake was calculated using the nutrition information provided on the manufacturers' product labels. As a manipulation check, participants were asked to how much they thought about their episodic events during the eating task using a Likert scale anchored by 1= not at all to 5 = very much.

## 1.3. Measures

**1.3.1. Dietary Restraint—**Dietary restraint refers to the desire to intentionally restrict food intake for weight regulation and it was assessed using the child version of the Dutch Eating Behavior Questionnaire (DEBQ-C) (van Strien & Oosterveld, 2008). This 33-item instrument has 3 subscales assessing restrained eating, emotional eating and external eating. Each item is scored on a five-point Likert scale 1 (never) to 5 (very often) and a mean item score was used to represent each subscale. The DEBQ-C scales have been shown to have good internal consistency and satisfactory factorial validity (van Strien & Oosterveld, 2008).

**1.3.2. Weight and Height—**Weight was measured using a digital scale (TANITA Corporation of America Inc., Arlington Heights, IL), and height was measured using a digital stadiometer (Measurement Concept and Quick Medical, North Bend, WA). Height and weight assessments were used to compute BMI ($kg/m^2$).

## 1.4. Analytical Plan

Preliminary analyses of variance (ANOVA) and Chi-Square tests were conducted to determine whether there were any group differences in subject characteristics. ANOVA was used to assess the manipulation check comparing how much participants thought about the episodic events during delay discounting and ad libitum eating tasks.

The effect of EFT versus ERT on delay discounting was analyzed by examining between group differences using analysis of variance (ANOVA). The effect of EFT versus ERT on energy intake was analyzed by examining between group differences using analysis of covariance (ANCOVA), with dietary restraint as the covariate. Dietary restraint was included as a covariate in the analysis of energy intake to test for a significant interaction between group and dietary restraint. A simple slopes analysis was used to explore the interaction between group and dietary restraint on energy intake. Effect sizes (ES) were calculated using

Cohen's *d* statistic. Data analyses were completed using SYSTAT version 11 (Systat Software, 2004).

## 2. Results

There were no significant group differences in participant characteristics (Table 1). Analyses of the manipulation check data revealed there were no group differences in how much participants thought about episodic events during the delay discounting task ($F(1, 40) = 0.38$, $p = 0.543$) or the *ad libitum* eating task ($F(1, 39) = 2.55$, $p = 0.118$).

Significant between group differences were observed in delay discounting ($F(1, 40) = 11.98$, $p = 0.001$, Cohen's $d = 1.069$), with EFT group showing less discounting (i.e. higher AUC values) than ERT group (0.68 + 0.25 vs. 0.42 + 0.23, mean + standard deviation, Figure 1A).

Significant between group differences were also observed for energy intake ($F(1, 38) = 4.26$, $p = 0.046$, Cohen's $d = 0.27$), with the EFT group consuming less calories than the ERT group (566.83 + 241.64 vs. 632.11 + 241.27, Figure 1B). In addition, as predicted, group interacted with dietary restraint ($F(1, 38) = 5.24$, $p = 0.028$). Simple slopes revealed a significant group difference in calories consumed for children with high dietary restraint (*Beta* = 196.25, $t = 2.06$, $p = 0.047$), but not in children with low dietary restraint (*Beta* =-124.09, $t = -1.24$, $p = 0.224$) (Figure 1C).

## 3. Discussion

Consistent with findings in adults (Daniel et al., 2013a, 2013b), overweight/obese children provided the EFT condition showed less delay discounting and ate less than the control recent thinking condition during the *ad libitum* eating task. Children with high dietary restraint (i.e. children motivated to restrict calorie intake for health) were more responsive to EFT and ate the least. Proposed mechanisms for EFT's effect are that imagining oneself at future events improves either the consideration of (Benoit et al., 2011) or the search for (Kurth-Nelson, Bickel, & Redish, 2012) the actual value of delayed outcomes during decision making.

We found that children with high dietary restraint were more responsive to EFT and ate the least as predicted. There is no research indicating that individuals with high dietary restraint have a peculiar talent for or previously developed EFT abilities. However, the desire to restrict dietary intake may be instrumental for EFT to reduce energy intake. Dietary restraint is a construct that reflects the degree to which an individual reports “eating less than desired in order to lose or maintain body weight” (van Strien & Oosterveld, 2008). Dietary restraint has been thought to distinguish obese individuals that are attempting to control their eating from obese individuals who are not (Bellisle et al., 2004; Cappelleri et al., 2009; Foster et al., 1998; Johnson, Pratt, & Wardle, 2012; Provencher, Drapeau, & Tremblay, 2003). We expected that an obese child who is not motivated to restrict calorie intake for health (low on dietary restraint), may consider resisting immediate gratification to be inconsequential in an *ad libitum* eating situation. Our results suggest that EFT could be a useful tool for overweight/obese children attempting to control their eating for weight loss.

The current study demonstrated EFT's effect of reducing energy intake during one eating episode in a controlled laboratory setting. Field experiments are needed to examine whether EFT's effect translates to eating episodes in natural eating environments over extended periods of time. A natural translation of the effect of EFT on delay discounting and energy intake (Daniel et al., 2013a, 2013b) in adults and children is to family-based pediatric obesity treatment. Being biased towards immediate gratification predicts diminished success with weight loss in family-based pediatric obesity treatment (Best et al., 2012). It is possible that customizing behavioral obesity treatment by incorporating EFT training for children with this immediate bias could increase success with weight loss. Incorporating EFT into a family-based obesity treatment (parent and child treated together) may be particularly beneficial for children. Children may receive additional benefit from their parents modeling of EFT and delay gratification, as children modify their delay gratification through modeling of adult delay of gratification (Bandura & Mischel, 1965).

The EFT and ERT paradigm used in this study used non-specific episodic future thinking and non-specific recent thinking, rather than episodic thinking that focused on eating. This provides the strongest case that activation of processes related to future thinking, rather than a specific behavioral goal, are contributing to the change in delay discounting and energy intake. All children used imagery they rated as positive, developed in collaboration with the investigators, and their voice cues were used to stimulate the imagery. However, the nonspecific nature of the EFT or ERT may mean that persons in either group were thinking of eating by association with the imagery they selected. This could occur for the ERT group when they recalled a recent positive event, or it could occur for the EFT group since many of the events they are looking forward to also involve eating. We have no way of determining whether the imagery cues elicited food images for either group, but recent on memory and eating would suggest that recalling eating or imagining eating could lead to reduction in energy intake during a current eating episode episodes (Higgs, 2002, 2008; Morewedge, Huh, & Vosgerau, 2010).

It is possible that the effectiveness of EFT could be amplified by utilizing future events and imagery that is related to personal goals. Future events could focus only on the outcome of achieving the goal or on the processes that facilitate goal attainment. As research suggests future thinking in real life is often geared towards future goals (Baird, Smallwood, & Schooler, 2011; Smallwood et al., 2011), incorporating elements of participants weight loss and health goals could amplify EFT's effect on energy intake. Furthermore, future thinking regarding personal goals leads to greater activation of brain regions involved in prospective thinking (D'Argembeau et al., 2010). Process simulation involves individuals imagining going through steps toward attaining a goal (Pham & Taylor, 1999; Taylor & Pham, 1998), and process simulations improve goal directed academic performance (Pham & Taylor, 1999). Outcome simulations that only involve imagining achieving a goal, also recruit brain regions that enable individuals to anticipate the affective consequences of attaining goals (Gerlach, Spreng, Madore, & Schacter, 2014). Research is needed that examines which type of future simulation is most effective for modifying energy intake.

In summary, the present study was designed to determine the effect of EFT on delay discounting and ad libitum energy intake in overweight/obese children. Results show that

children in the EFT group showed less delay discounting and consumed less food than the control group. This research extends our knowledge of the EFT effect to demonstrate that EFT has a similar effect on decision making and energy intake in children as it does in adults. These finding have implications for obesity treatments like family-based interventions that attempt to improve eating behaviors in adults and children simultaneously. It suggests that the same EFT technique could be used to improve the ability to resist immediate gratification in both parent and child.

## Acknowledgments

We appreciate Shirin Aghazadeh and Morgan Pratte for assisting with participant recruitment and Katelyn Carr for feedback on study design.

**Role of Funding Sources**: This research was funded in part by Grant 1U01 DK088380 from the National Institute of Diabetes and Digestive and Kidney Diseases to Dr. Epstein.

## Appendix

**Foods used in the *ad libitum* taste test[1]**

| | Serving Size | Weight (g) | Energy (kcals) | Energy Density (Kcal/g) |
|---|---|---|---|---|
| ***Food*** | | | | |
| Hershey's Milk Chocolate[2] | ~6 sections | 47.60 | 244.18 | 5.13 |
| Reese's Mini Peanut Butter Cups (Unwrapped)[3] | ~11 cups | 30.60 | 156.98 | 5.13 |
| Twizzlers Strawberry Liquorice[4] | ~ 4 sticks | 51.60 | 181.12 | 3.51 |
| Original Fruit Skittles[5] | ~54 pieces | 56.20 | 228.17 | 4.06 |
| Wegmans Gummi Bears[6] | ~24 bears | 91.90 | 329.92 | 3.59 |
| Stauffer's Animal Crackers (Iced)[7] | ~10 crackers | 41.95 | 173.67 | 4.14 |

[1] Values are from the package labels as of May, 2013 and may represent some rounding error.

[2] The Hershey Company, Hershey, PA

[3] The Hershey Company, Hershey, PA

[4] The Hershey Company, Hershey, PA

[5] William Wrigley Jr. Company, Chicago, IL

[6] Wegmans Food Market, Gates, NY

[7] Stauffer's Biscuit Company, York, PA

## References

Appelhans BM, Woolf K, Pagoto SL, Schneider KL, Whited MC, Liebman R. 2011; Inhibiting food reward: Delay discounting, food reward sensitivity, and palatable food intake in overweight and obese women. Obesity. 19:2175–2182. [PubMed: 21475139]

Appelhans BM, Waring ME, Schneider KL, Pagoto SL, DeBiasse MA, Whited MC, Lynch EB. 2012; Delay discounting and intake of ready-to-eat and away-from-home foods in overweight and obese women. Appetite. 59:576–584. [PubMed: 22819735]

Atance CM. 2008; Future thinking in young children. Current Directions in Psychological Science. 17:295–298.

Atance CM, O'Neill DK. 2001; Episodic future thinking. Trends in Cognitive Sciences. 5:533–539. [PubMed: 11728911]

Atance CM, O'Neill DK. 2005; The emergence of episodic future thinking in humans. Learning and Motivation. 36:126–144.

Baird B, Smallwood J, Schooler JW. 2011; Back to the future: Autobiographical planning and the functionality of mind-wandering. Consciousness and Cognition. 20:1604–1611. [PubMed: 21917482]

Bandura A, Mischel W. 1965; Modification of self-imposed delay of reward through exposure to live and symbolic models. Journal of Personality and Social Psychology. 2:698–705. [PubMed: 4158333]

Banich MT, De La Vega A, Andrews-Hanna JR, Mackiewicz Seghete K, Du Y, Claus ED. 2013; Developmental trends and individual differences in brain systems involved in intertemporal choice during adolescence. Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors. 27:416–430. [PubMed: 23586454]

Bellisle F, Clément K, Le Barzic M, Le Gall A, Guy-Grand B, Basdevant A. 2004; The Eating Inventory and body adiposity from leanness to massive obesity: a study of 2509 adults. Obesity Research. 12:2023–2030. [PubMed: 15687404]

Benoit RG, Gilbert SJ, Burgess PW. 2011; A neural mechanism mediating the impact of episodic prospection on farsighted decisions. The Journal of Neuroscience. 31:6771–6779. [PubMed: 21543607]

Best JR, Theim KR, Gredysa DM, Stein RI, Welch RR, Saelens BE, et al. Wilfley DE. 2012; Behavioral economic predictors of overweight children's weight loss. Journal of Consulting and Clinical Psychology. 80:1086–1096. [PubMed: 22924332]

Bickel WK, Marsch LA. 2001; Toward a behavioral economic understanding of drug dependence: Delay discounting processes. Addiction. 96:73–86. [PubMed: 11177521]

Björntorp P. 1990; “Portal” adipose tissue as a generator of risk factors for cardiovascular disease and diabetes. Arteriosclerosis, Thrombosis, and Vascular Biology. 10:493–496.

Bonato DP, Boland FJ. 1983; Delay of gratification in obese children. Addictive Behaviors. 8:71–74. [PubMed: 6880927]

Boyer P. 2008; Evolutionary economics of mental time travel? Trends in Cognitive Sciences. 12:219–224. [PubMed: 18468941]

Braet C, Van Strien T. 1997; Assessment of emotional, externally induced and restrained eating behaviour in nine to twelve-year-old obese and non-obese children. Behaviour Research and Therapy. 35:863–873. [PubMed: 9299807]

Cappelleri JC, Bushmakin AG, Gerber RA, Leidy NK, Sexton CC, Lowe MR, Karlsson J. 2009; Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. International Journal of Obesity. 33:611–620. [PubMed: 19399021]

Daniel TO, Stanton CM, Epstein LH. 2013a; The future is now: Comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. Appetite. 71:120–125. [PubMed: 23917063]

Daniel TO, Stanton CM, Epstein LH. 2013b; The future is now: Reducing impulsivity and energy intake using episodic future thinking. Psychological Science. 24:2339–2342. [PubMed: 24022653]

Davis C, Patte K, Curtis C, Reid C. 2010; Immediate pleasures and future consequences. A neuropsychological study of binge eating and obesity. Appetite. 54:208–213. [PubMed: 19896515]

Dixon MR, Marley J, Jacobs EA. 2003; Delay discounting by pathological gamblers. Journal of Applied Behavior Analysis. 36:449–458. [PubMed: 14768665]

D'Argembeau A, Stawarczyk D, Majerus S, Collette F, Van der Linden M, Feyers D, et al. Salmon E. 2010; The neural basis of personal goal processing when envisioning future events. Journal of Cognitive Neuroscience. 22:1701–1713. [PubMed: 19642887]

Epstein LH, Jankowiak N, Fletcher KD, Carr KA, Nederkoorn C, Raynor H, Finkelstein E. 2014; Women who are motivated to eat and discount the future are more obese. Obesity. 22:1394–1399. [PubMed: 24311480]

Fedoroff I, Polivy J, Herman P. 1997; The effect of pre-exposure to food cues on the eating behavior of restrained and unrestrained eaters. Appetite. 28:33–47. [PubMed: 9134093]

Fedoroff I, Polivy J, Herman P. 2003; The specificity of restrained versus unrestrained eaters' responses to food cues: general desire to eat, or craving for the cued food? Appetite. 41:7–13. [PubMed: 12880616]

Foster GD, Wadden TA, Swain RM, Stunkard AJ, Platte P, Vogt RA. 1998; The Eating Inventory in obese women: clinical correlates and relationship to weight loss. International Journal of Obesity and Related Metabolic Disorders. 22:778–785. [PubMed: 9725638]

Gerlach KD, Spreng RN, Madore KP, Schacter DL. 2014; Future planning: default network activity couples with frontoparietal control network and reward-processing regions during process and outcome simulations. Social Cognitive and Affective Neuroscience. 9:1942–1951. [PubMed: 24493844]

Green L, Fry AF, Myerson J. 1994; Discounting of delayed rewards: A life-span comparison. Psychological Science. 5:33–36.

Higgs S. 2002; Memory for recent eating and its influence on subsequent food intake. Appetite. 39:159–166. [PubMed: 12354684]

Higgs S. 2008; Cognitive influences on food intake: the effects of manipulating memory for recent eating. Physiology & Behavior. 94:734–739. [PubMed: 18486159]

Hill JO, Melanson EL, Wyatt HT. 2000; Dietary fat intake and regulation of energy balance: implications for obesity. The Journal of Nutrition. 130:284S–288S. [PubMed: 10721889]

Johnson F, Pratt M, Wardle J. 2012; Dietary restraint and self-regulation in eating behavior. International Journal of Obesity. 36:665–674. [PubMed: 21829162]

Kurth-Nelson Z, Bickel W, Redish AD. 2012; A theoretical account of cognitive effects in delay discounting. The European Journal of Neuroscience. 35:1052–1064. [PubMed: 22487035]

Larson N, Neumark-Sztainer D, Laska MN, Story M. 2011; Young adults and eating away from home: associations with dietary intake patterns and weight status differ by choice of restaurant. Journal of the American Dietetic Association. 111:1696–1703. [PubMed: 22027052]

Morewedge CK, Huh YE, Vosgerau J. 2010; Thought for food: Imagined consumption reduces actual consumption. Science. 330:1530–1533. [PubMed: 21148388]

Myerson J, Green L, Warusawitharana M. 2001; Area under the curve as a measure of discounting. Journal of the Experimental Analysis of Behavior. 76:235–243. [PubMed: 11599641]

Peters J, Büchel C. 2010; Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. Neuron. 66:138–148. [PubMed: 20399735]

Pham LB, Taylor SE. 1999; From thought to action: Effects of process-versus outcome-based mental simulations on performance. Personality & Social Psychology Bulletin. 25:250–260.

Provencher V, Drapeau V, Tremblay A. 2003; Eating behaviors and indexes of body composition in men and women from the Quebec family study. Obesity. 11:783–792.

Rollins BY, Dearing KK, Epstein LH. 2010; Delay discounting moderates the effect of food reinforcement on energy intake among non-obese women. Appetite. 55:420–425. [PubMed: 20678532]

Schacter DL, Addis DR, Buckner RL. 2008; Episodic simulation of future events. Annals of the New York Academy of Sciences. 1124:39–60. [PubMed: 18400923]

Seeyave DM, Coleman S, Appugliese D, Corwyn RF, Bradley RH, Davidson NS, et al. Lumeng JC. 2009; Ability to delay gratification at age 4 years and risk of overweight at age 11 years. Archives of Pediatrics & Adolescent Medicine. 163:303–308. [PubMed: 19349558]

Smallwood J, Schooler JW, Turk DJ, Cunningham SJ, Burns P, Macrae CN. 2011; Self-reflection and the temporal focus of the wandering mind. Consciousness and Cognition. 20:1120–1126. [PubMed: 21277803]

Steinberg L, Graham S, O'Brien L, Woolard J, Cauffman E, Banich M. 2009; Age differences in future orientation and delay discounting. Child Development. 80:28–44. [PubMed: 19236391]

SystatSoftware. Systat (Version 11). Richmond, CA: SYSTAT Software, Inc; 2004.

Taylor SE, Pham LB. 1998; The effect of mental simulation on goal-directed performance. Imagination, Cognition and Personality. 18:253–268.

Temple JL, Legierski CM, Giacomelli AM, Salvy SJ, Epstein LH. 2008; Overweight children find food more reinforcing and consume more energy than do nonoverweight children. The American Journal of Clinical Nutrition. 87:1121–1127. [PubMed: 18469229]

Van Strien T, Oosterveld P. 2008; The children's DEBQ for assessment of restrained, emotional, and external eating in 7 to 12 year old children. The International Journal of Eating Disorders. 41:72–81. [PubMed: 17634965]

Wang X, Dvorak RD. 2010; Sweet Future Fluctuating Blood Glucose Levels Affect Future Discounting. Psychological Science. 21:183–188. [PubMed: 20424042]

Wardle J, Guthrie CA, Sanderson S, Rapoport L. 2001; Development of the children's eating behaviour questionnaire. Journal of Child Psychology and Psychiatry, and Allied Disciplines. 42:963–970.

Weller RE, Cook EW, Avsar KB, Cox JE. 2008; Obese women show greater delay discounting than healthy-weight women. Appetite. 51:563–569. [PubMed: 18513828]

Winter J, Wuppermann A. 2014; Do they know what is at risk? Health risk perception among the obese. Health Economics. 23:564–585. [PubMed: 23661580]

## Highlights

- Episodic future thinking (EFT) improves delay of gratification in adults.
- EFT's effects on delay of gratification have not been examined in children.
- Our experiment examined EFT's effects in overweight/obese 9 to 14 year olds.
- Results showed EFT led to less delay discounting and lowered energy intake.
- EFT reduced food intake the most when there was a higher desire to restrict intake.

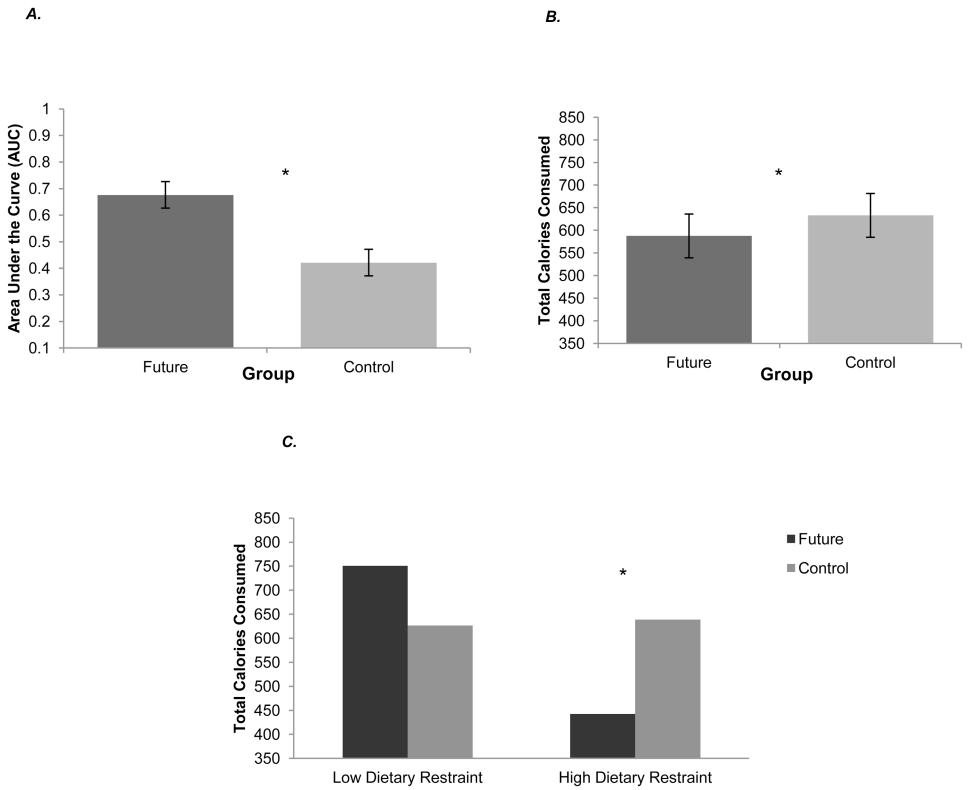


**Figure 1.**

A) Mean area-under-the-curve (AUC) values (mean + SEM) for discounting of delayed rewards as a function of condition. B) Mean caloric intake (mean + SEM) as a function of condition. C) Mean caloric intake estimates as a function of condition and dietary restraint from simple slope analysis. An asterisk marks a significant difference ($p < 0.05$).

## Table 1
### Descriptive Data of Individual Differences Variables

| | Mean (SD) | | |
|---|---|---|---|
| | **EFT (N=21)** | **Control (N=21)** | **P** |
| ***Age*** | 12.13 (1.53) | 12.33 (1.36) | 0.65 |
| ***zBMI*** | 1.74 (0.42) | 1.70 (0.40) | 0.77 |
| ***Dutch Eating Behavior Questionnaire Child Version (DEBQ-C)*** | | | |
| Restraint | 2.05 (0.52) | 1.92 (0.49) | 0.39 |
| External Eating | 2.31 (0.47) | 2.37 (0.48) | 0.71 |
| Emotional Eating | 1.25 (0.35) | 1.25 (0.35) | 1.00 |
| | **N (%)** | | |
| ***Race*** | | | 0.21 |
| Caucasian | 16 (38.10) | 19 (45.24) | |
| Non-Caucasian | 5 (11.90) | 2 (4.76) | |
| ***Sex*** | | | 0.22 |
| Male | 9 (21.43) | 12 (28.57) | |
| Female | 13 (30.95) | 8 (19.05) | |