



# Episodic future thinking reduces delay discounting and energy intake in children



Tinuke Oluoyomi Daniel<sup>a,b</sup>, Michele Said<sup>a</sup>, Christina M. Stanton<sup>a</sup>, Leonard H. Epstein<sup>a,b,\*</sup>

<sup>a</sup> Department of Pediatrics, University at Buffalo School of Medicine and Biomedical Sciences, United States

<sup>b</sup> Department of Community Health and Health Behaviors, University at Buffalo School of Public Health and Health Professions, United States

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## 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 that 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 that EFT may be useful in pediatric obesity treatment programs to help children regulate energy intake.

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## 1. Introduction

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 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 and 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,

\* Corresponding author at: Department of Pediatrics, School of Medicine and Biomedical Sciences, University at Buffalo, Farber Hall, Room G56, 3435 Main Street, Building #26, Buffalo, NY 14214-3000, United States. Tel.: +1 716 829 3400; fax: +1 716 829 3993.

E-mail address: LHENET@acsu.buffalo.edu (L.H. Epstein).

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, Stanton, & Epstein, 2013b; Daniel et al., 2013a). While EFT ability emerges between 3 and 5 years of age (Atance & O'Neill, 2005), little is known about the 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.

## 2. Methods

### 2.1. Participants

We studied 42 overweight/obese 9–14 year-old children (Body Mass Index (BMI)  $\geq$  85th percentile for children of the same age and sex, mean BMI percentile  $\pm$  standard deviation =  $93.91 \pm 3.18$ ). 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.

### 2.2. 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 Behavior 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.

#### 2.2.1. 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.

#### 2.2.2. 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 h. 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.

#### 2.2.3. 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 et al., 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.

#### 2.2.4. 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 A). Second, sessions were scheduled in between meals (at least 90 min 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 min, 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 min and participants provided ratings of taste and food texture. We presented from 1275.8 to 1352.3 cal with the option of extra portions (up to another 1352.3 cal). 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 0.01 g sensitivity (Denver Instrument XP-300, Denver Instrument Company, Arvada, 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.

### 2.3. Measures

#### 2.3.1. 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 ranging from 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).

#### 2.3.2. 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 ( $\text{kg}/\text{m}^2$ ).

### 2.4. 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 (SystatSoftware, 2004).

## 3. Results

There were no significant group differences in participant characteristics (Table 1). Analyses of the manipulation check data revealed that 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 ( $F(1, 40) = 11.98, p = 0.001, \text{Cohen's } d = 1.069$ ), with

**Table 1**  
Descriptive data of individual differences variables.

	Mean (SD)		<i>p</i>
	EFT ( <i>N</i> = 21)	Control ( <i>N</i> = 21)	
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 (%)			
	EFT ( <i>N</i> = 21)	Control ( <i>N</i> = 21)	<i>p</i>
Race			
Caucasian	16 (38.10)	19 (45.24)	0.21
Non-Caucasian	5 (11.90)	2 (4.76)	
Sex			
Male	9 (21.43)	12 (28.57)	0.22
Female	13 (30.95)	8 (19.05)	

the EFT group showing less discounting (i.e. higher AUC values) than the ERT group ( $0.68 \pm 0.25$  vs.  $0.42 \pm 0.23$ , mean  $\pm$  standard deviation, Fig. 1A).

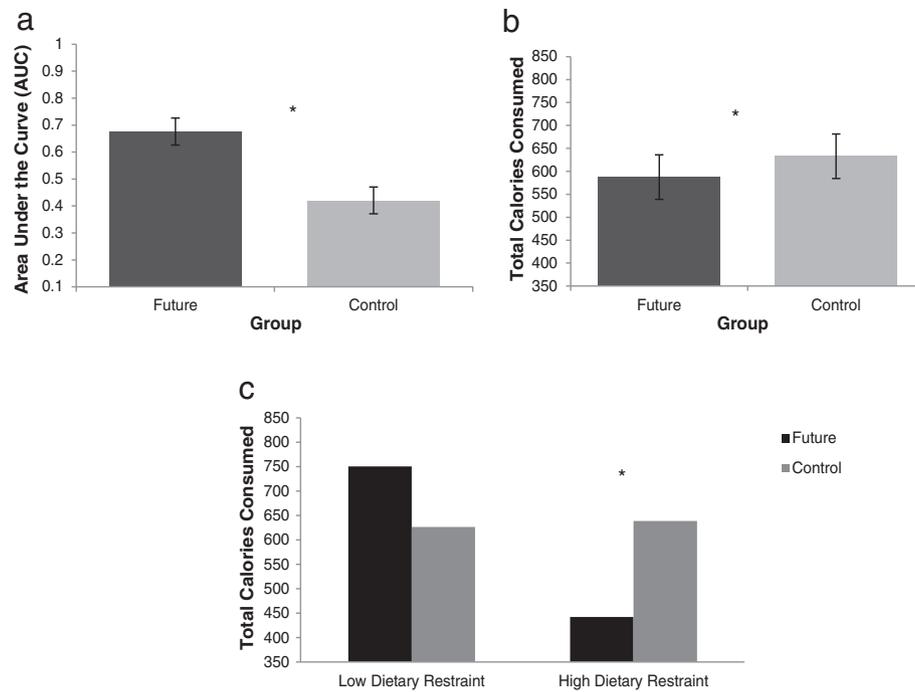
Significant between group differences were also observed for energy intake ( $F(1, 38) = 4.26, p = 0.046, \text{Cohen's } d = 0.27$ ), with the EFT group consuming less calories than the ERT group ( $566.83 \pm 241.64$  vs.  $632.11 \pm 241.27$ , Fig. 1B). In addition, as predicted, group interacted with dietary restraint ( $F(1, 38) = 5.24, p = 0.03$ ). Simple slopes revealed a significant group difference in calories consumed for children with high dietary restraint ( $\text{Beta} = 196.25, t = 2.06, p = 0.047$ ), but not in children with low dietary restraint ( $\text{Beta} = -124.09, t = 1.24, p = 0.22$ ) (Fig. 1C).

## 4. 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



**Fig. 1.** A) Mean area-under-the-curve (AUC) values (mean  $\pm$  SEM) for discounting of delayed rewards as a function of condition. B) Mean caloric intake (mean  $\pm$  SEM) as a function of condition. C) Mean caloric intake estimates as a function of condition and dietary restraint from simple slopes analysis. An asterisk marks a significant difference ( $p < 0.05$ ).

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, is 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 non-specific 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 study on memory and eating would suggest that recalling eating or imagining eating could lead to reduction in energy intake during a current eating episode (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'Armentano et al., 2010). Process simulation involves individuals imagining going through steps towards 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 findings 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.

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#### 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.

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### Appendix A. Foods used in the ad libitum taste test<sup>1</sup>

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

<sup>1</sup>Values are from the package labels as of May, 2013 and may represent some rounding error. <sup>2</sup>The Hershey Company, Hershey, PA. <sup>3</sup>The Hershey Company, Hershey, PA. <sup>4</sup>The Hershey Company, Hershey, PA. <sup>5</sup>William Wrigley Jr. Company, Chicago, IL. <sup>6</sup>Wegmans Food Market, Gates, NY. <sup>7</sup>Stauffer's Biscuit Company, York, PA.

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