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Mothers' DASH diet adherence and food purchases after week-long episodic future thinking intervention

Kelseanna Hollis-Hansen^{a,b,*}, Jennifer Seidman^c, Sara O'Donnell^c, Leonard H. Epstein^c

^aDepartment of Population Health, University of Texas at Austin, Dell Medical School, Austin, TX, USA

^bUniversity of Texas at Austin, Steve Hicks School of Social Work, Austin, TX, USA

^cDepartment of Pediatrics, Division of Behavioral Medicine, University at Buffalo, Jacobs School of Medicine and Biomedical Sciences, Buffalo, NY, USA

Abstract

Prospersion has helped participants forego the temptation to buy and eat higher calorie nutrient poor foods in favor of buying and eating fewer calories and healthier macronutrient profiles in laboratory tasks and brief field studies. This pilot study examines whether episodic future thinking (EFT) improves mothers' dietary behavior and food purchasing over a longer 7–10-day period. The study utilized a 2×2 factorial design with mothers ($N = 60$) randomized to EFT or standardized episodic thinking (SET) crossed with dietary approaches to stop hypertension (DASH) diet education or a food safety education control. Participants listened to their cues (e.g., recordings of themselves imagining a future event or recalling a past episode) using a mobile ecological momentary intervention (EMI) tool and returned to complete a follow-up dietary recall and submit food receipts. Results showed diets of mothers in the EFT groups became more concordant with the DASH diet ($\eta_p^2 = 0.08$, $p < .05$) than mothers in the SET group. When considering food purchases for the family, there was an EFT effect on milligrams of sodium purchased ($\eta_p^2 = 0.07$, $p < .05$) and a trend towards a decrease in grams of fat purchased ($\eta_p^2 = 0.06$, $p = .06$), however, these findings were no longer significant after correcting for multiple comparisons. There were no DASH education effects and no DASH by EFT interactions observed. The dietary intake and food purchasing results should be replicated in larger more representative samples.

Keywords

Prospersion; Eating behavior; Episodic future thinking; Grocery shopping

*Corresponding author. Department of Population Health, University of Texas at Austin, Dell Medical School, 1601 Trinity St., Bldg. B, Stop Z0500, Austin, TX, 78701, USA, kelseanna.hollishansen@austin.utexas.edu (K. Hollis-Hansen).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2020.104757>.

1. Introduction

Episodic future thinking (EFT) is a cognitive capability that enables one to mentally simulate a potential future (Atance, 2001). People vary in how frequently and vividly they imagine the future as well as how much weight they give to larger future rewards while making decisions. A focus on or preference for more immediate gratification over future benefit (e.g. delay discounting) has been associated with a number of maladaptive behaviors and poor health outcomes (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). It has been hypothesized that EFT may be an effective self-regulatory tool due to its demonstrated ability to 1) improve one's mood (e.g. reduce anxiety) while making a decision, 2) increase the valuation of larger-later rewards, 3) improve prospective memory, and 4) increase one's consideration of and planning for the future (Schacter, 2017). A burgeoning area of research instructs participants to simulate, write, or recall EFT narratives (i.e. cues) while completing DD tasks or engaging in health-related behaviors (e.g. smoking, eating, drinking). These EFT interventions have been associated with numerous beneficial outcomes, such as reduced delay discounting (DD) (Rung & Madden, 2018a), reduced snack food demand in a hypothetical purchasing task (Sze, Stein, Bickel, Paluch, & Epstein, 2017), reduced caloric intake in ad-libitum eating experiments in the laboratory (Daniel, Said, Stanton, & Epstein, 2015; Daniel, Stanton, & Epstein, 2013; Dassen, Jansen, Nederkoorn, & Houben, 2016) and reduced caloric intake in a food court (O'Neill, Daniel, & Epstein, 2016).

EFT has also helped parents with overweight and obesity lower BMI during a four-week family-based weight loss intervention (Sze, Daniel, Kilanowski, Collins, & Epstein, 2015). However, children in the EFT condition did not show differential changes in BMI in comparison to controls (Sze et al., 2015). These results suggest that training families in EFT will not automatically lead to an improvement in children's eating or activity behaviors. Thus, when working with families, it may be advantageous to go beyond traditional training in eating and exercise control to target parent's shopping behavior as a way to improve the shared home food environment (van Ansem, Schrijvers, Rodenburg, & van de Mheen, 2014).

Following the NIH Stage Model of Behavior Change (Onken, Carroll, Shoham, Cuthbert, & Riddle, 2014), we initiated a series of studies to test whether EFT could improve mother's household food purchases. In two earlier laboratory studies that used a simulated online shopping task, we found that EFT helped mothers with overweight and obesity to purchase groceries with fewer calories and healthier macronutrient profiles (Hollis-Hansen, Seidman, O'Donnell, & Epstein, 2019). These findings were then replicated in a three-day field study where mothers listened to their cues from their preferred device and shopped at their favored food retailers in the real world (Hollis-Hansen et al., 2020).

Extending upon the earlier work, one way to enhance the effectiveness and translation of EFT may be to combine it with dietary education that provides guidance on what to buy and eat, in addition to the self-regulatory assistance EFT may provide. The Dietary Approaches to Stop Hypertension (DASH) diet focuses dieters on eating vegetables, fruits, and whole grains, and limiting foods high in sodium, saturated fat, and sweets while not expressly

restricting any specific macronutrients or food items. Dieters are instructed to consume 2000 calories per day and 1500–2300 mg of sodium (< 1 teaspoon of salt) each day (Campbell, 2017). DASH is a relatively simple dietary approach to follow that has consistently proven effective at weight loss (Soltani, Shirani, Chitsazi, & Salehi-Abargouei, 2016), therefore it could help provide participant's a frame of reference for what to buy and eat during the intervention period.

This pilot study was designed to advance our knowledge of using EFT to improve dietary behavior and food purchasing. Female shoppers with children were randomized to one of four groups in a factorial design that studied EFT versus standardized episodic recent thinking (SET) crossed with DASH dietary advice versus food safety advice. In addition to studying female shopper's food purchases over a longer 7–10-day period, we also studied the women's dietary intake to assess if their dietary intake and food purchasing were influenced by EFT and/or DASH dietary education. We focused on mothers as they are the primary food shoppers and preparers for their family and a major influence on their children's eating behavior (Schaeffer, 2019).

We hypothesized that EFT participants would have better adherence to the DASH diet than the SET control group. We did not expect brief DASH diet education alone to influence dietary behavior, but we did hypothesize that there would be an EFT by DASH interaction, such that EFT would have a greater effect on DASH diet adherence in the EFT participants that received DASH education than either of the SET participants or the EFT participants that received food safety education. We also hypothesized that EFT groups would purchase fewer calories and healthier nutrient profiles than SET controls and that EFT would again interact with DASH education leading to the greatest improvement in foods purchased over the week-long intervention for those who received EFT accompanied by DASH diet education.

Most studies of EFT and DD instruct participants to read and recall their cues before or while making decisions during the DD task to modify temporal discounting. In recent work, researchers have not observed changes in discounting when cues are not presented during the DD tasks (Hollis-Hansen et al., 2019; Rung & Madden, 2019; Mellis et al., 2019). It is possible that more extensive experience with EFT may change temporal discounting even when no cues are presented. Rather than replicate the effects of EFT training on temporal discounting when EFT cues are presented, we tested whether one week of EFT cue recalls would change default thinking and improve DD without cues. Our exploratory hypothesis was that there would be an independent main effect of uncued EFT on change in DD from Time 1 to Time 2.

2. Methods

2.1. Participants

2.1.1. Sampling and eligibility screener—Participants were recruited using public advertisements on Facebook, Craigslist, and bulletin boards and advertisements were sent via e-mail to potential participants retrieved from the Division of Behavioral Medicine's recruitment database. Advertisements included a clickable link and a scannable QR code

which brought up the study's eligibility screener. The eligibility screener included questions on participant demographics to ensure those interested met age criteria (Gage-Bouchard & Devine, 2014) and had a child between the age of 2–19 living in the home for whom they buy groceries. The screener also included a brief health history assessment, one item on prior participation in previous studies, and one item on whether the participant was interested in buying healthier foods for their family.

2.1.2. Inclusion and exclusion criteria—Inclusion criteria were mothers between the ages of 24 and 55 with a body mass index (BMI) greater than 24.9 and an interest in making healthier food purchases for their family. 62 people were randomized, and our final sample included 60 participants. Two participants were excluded from the final sample due to one missing follow-up data and evidence that the other provided inaccurate gender data.

44 additional people completed the study screener, but were excluded. Exclusion criteria included recent participation (< 6 months) in an EFT study, eating disorders or dietary restrictions that may influence how the person buys and consumes food, BMI below 24.9 (31 people), currently pregnant (4 people), self-reported untreated mental or physical ailments (e.g. central auditory processing disorder, untreated bipolar disorder) that could influence ability to generate future cues (Gamble, Moreau, Tippet, & Addis, 2019) (6 people), and bariatric surgery as it restricts dietary behavior (3 people).

2.1.3. Study participants and ethical approval—Participants were mothers age 28–53 with an average of 4.1 people (2.2 children) living in the home for whom they buy groceries. Over a quarter of the participants (26.7%) were people of color and participants had a mean education of 15.8 years. About a quarter of the sample (25.8%) reported currently receiving some form of cash assistance (e.g. WIC, SNAP, TANF). This study was approved by the University at Buffalo Social and Behavioral Sciences Institutional Review Board (#STUDY00003260). Detailed participant characteristics are presented by group in Table 1.

2.2. Procedures

2.2.1. Scheduling and randomization—Eligible participants were contacted and invited to schedule an appointment from one to three weeks from first contact to provide the participant time to collect one week's worth of food receipts before the baseline appointment. Ahead of their baseline appointment, participants received two YouTube videos by e-mail. One video explained the study expectations and the other provided instructions on baseline receipt collection and annotation procedures, which were adapted from the SHOPPER study (French, Tangney, Crane, Wang, & Appelhans, 2019). Participants were randomized to one of four groups in a 2 × 2 factorial design that crossed EFT with DASH diet information. The four groups were EFT with DASH diet education, EFT with food safety education, SET with DASH diet education, or SET with food safety education.

2.2.2. Baseline procedures – food receipt interview and baseline questionnaires—At the baseline appointment participants' receipts and completed food receipt forms were checked to confirm that the products described matched the receipts and

that the food item descriptions were clear to the researcher (e.g. item quantity, brand listed if applicable, whether the food was low fat, low salt, or low sugar if applicable). Following the receipt interview, participants completed measures of general demographics (Gage-Bouchard & Devine, 2014), food insecurity (Blumberg, Bialostosky, Hamilton, & Briefel, 1999), delay discounting (Frye, Galizio, Friedel, DeHart, & Odum, 2016), general prospective thinking (Strathman, Gleicher, Boninger, & Edwards, 1994), shopping habits (Minaker et al., 2016), perceived stress (Lee, 2012), and baseline fruit and vegetable intake and usual consumption of sit-down and fast-food restaurant meals (Moore et al., 2015).

2.2.3. Baseline procedures - mobile game task—Participants played mobile application games on a tablet, an experience which becomes the episodic event the control group goes on to describe later in the laboratory session. Details on the mobile game task and control manipulation have been extensively described in prior publications and validated in a study on EFT and DD (Hollis-Hansen et al., 2019). After participants finished playing mobile games on the tablet independently they generated their EFT or SET cues with a research assistant at a computer.

2.2.4. Baseline procedures – creating cues—Generating future cues involves episodic simulation wherein the participant is asked to positively and vividly imagine a future event or experience that is planned or that one anticipates could happen in their future (Szpunar, 2010). EFT cues are a short personal narrative (3–5 sentences) describing the episodic simulation and includes who is with the participant, what they are doing during the event, where they are for the event and how they expect to be feeling in that moment (“*In about six months I am riding my new red bike around the park with my family. I am enjoying the beautiful weather and the wind in my hair as I pedal alongside my daughters. I am feeling happy.*”). The cue is created to help the participant re-engage in the episodic future simulation whenever they read or listen to it. Generating the SET cues followed a similar process, but instead of focusing on a positive future event, the participant was asked to describe the recent experience of playing mobile games in the laboratory (“*About 5 min ago I was playing Bubble Witch on a tablet. I was dressed as a purple witch and I was using a wand to pop bubbles and free the owls. I was feeling excited as I cleared each board.*”). Before moving forward with the remaining procedures, the research assistant confirmed that EFT cues were specifically future-oriented and that the EFT or SET cues were generally positive and well described. Following cue generation, participants rated their cues on their ability to vividly imagine the event and how much they liked the episode. Research assistants were instructed to ask the participants to choose a different event or play an additional game if the cue were rated below a 3 for liking or vividness, but that did not happen among the present sample. Text (e.g. typed) cues were saved to the participant’s locked data folder. Immediately following cue generation, the research staff recorded the participant reading their cues out loud using Audacity, a voice recording program.

2.2.5. Baseline procedures – DASH or food safety education video—Participants randomized to the DASH diet intervention watched a 10-min YouTube video on the diet. The video was developed by a registered dietitian and included an overview of the diet’s origin, the diet’s continued success at weight loss, the diet’s guidelines (e.g. number

of servings of each food group, what a serving looks like, etc.), and what foods are or are not encouraged while on the diet. Participants randomized to the food safety groups watched a 10-min video developed by the United States Food and Drug Administration which included information on safe food handling, preparation, and storage. While the participant watched the videos, research assistants uploaded the participants text and audio cues onto MAMRT (Mobile Audio Manager and Response Tracker), the study's ecological momentary intervention (EMI) platform (Sze et al., 2015).

2.2.6. Baseline procedures – ASA 24-h food recall—Participants completed the online ASA-24 food consumption recall with guidance from a study staff member. The ASA-24 is a reliable and valid approach to measuring dietary intake (Kirkpatrick et al., 2019). During the recall participants provided detailed information on all of the foods and beverages they consumed over the past 24 h.

2.2.7. Baseline procedures – instructions on the remaining study procedures—Participants were instructed to use their cues at least once per day, with an emphasis on using their cues before they went food shopping. Appointments were scheduled for 7–10 days from the baseline appointment, but in three instances follow-up appointments were rescheduled. In these instances, participants were instructed to only use their cues and collect food receipts for the week before their new follow-up appointment date to reduce variability in the number of cue recalls, the number of receipts provided and the amount of food purchased. The variable “time between appointments” can be found in Table 1. Participants were also provided with three tip sheets to take home. Participants in the DASH education group received tip sheets created by registered dietitians on DASH recommendations (e.g. serving sizes by food group) and foods to buy and avoid. Participants in the food safety group received tip sheets created by the USDA on safe food storage and cooking procedures.

2.2.8. Procedures at home – ecological momentary intervention (EMI) tool variables—Participants received daily text reminders to log-in to MAMRT, to listen to their cues from their preferred device, and to use their cues before food shopping. The variable “number of cue recalls” indicates the number of times participants logged into MAMRT between appointments and can also be found in Table 1. Other MAMRT related variables include “attention to cue”, which is the participants report of how much they were paying attention to their cue while they completed each recall and “vividness of cue”, which is the participants report of how vividly they could picture the episodes during cue recall.

2.2.9. Follow-up procedures – food receipt collection and interview—Participants were called or texted (depending on their preferred method of contact) a reminder to bring receipts and food receipt forms to their follow-up appointment. During the follow-up appointment, participants submitted their food receipts for the study period and completed a second food receipt interview with a study staff member.

2.2.10. Follow-up procedures – other measures collected at follow-up and payment—The same uncued DD task and the ASA 24-h dietary recall completed at baseline were administered again at follow-up. Lastly, participants had their height and

weight measured using a Seca stadiometer and a Tanita scale. Participants were paid \$30 at the end of their first appointment and \$50 at the end of their second appointment.

2.3. Measures

Demographics were measured using questions from the McArthur Network, a widely used and validated measure (Gage-Bouchard & Devine, 2014). Food insecurity was measured using a 6-item short-form measure of food insecurity (Blumberg et al., 1999). Delay discounting was measured using an online adjusting amount DD task, which asks participants to indicate whether they would prefer a smaller reward immediately or a larger reward at a specific time point in the future (Frye et al., 2016). DD was scored using area under the curve (AUC) whereby a lower AUC (closer to 0) indicates steeper discounting of the delayed reward while a higher AUC (closer to 1) indicates a preference for the larger-later reward.

General prospective thinking was measured using the consideration of future consequences (CFC) scale, a reliable and valid trait measure of how often one considers the future and how much weight they put into future outcomes in day-to-day decision-making (Strathman et al., 1994). How frequently one shops at various food retailers (e.g. supermarkets, supercenters, corner stores) was assessed by the Shopping Habits Survey, that has demonstrated reliability and construct validity (Minaker et al., 2016). Perceived stress was measured using the perceived stress scale, a psychometrically-valid and reliable measure of one's perceived personal stress and their ability to cope with the stressors they may be experiencing (Lee, 2012). 7-items were taken from the Behavioral Risk Factor Surveillance System (BRFSS) questionnaire to provide an overview of participant's baseline fruit and vegetable intake and usual consumption of sit-down and fast-food restaurant meals (Moore et al., 2015).

2.3.1. DASH diet adherence scores—We computed DASH diet adherence scores from the nutrient data provided by the ASA-24-h food consumption recall (Kirkpatrick et al., 2019) using Dixon's method for scoring dietary adherence (Dixon et al., 2007) which involves providing 1 point for meeting or no points for failing to meet food group recommendations and summing the points to get a total score which can range from 0 to 9. The total DASH score from Dixon's method has been found to be a reliable method for capturing how well one's dietary intake maps on to the DASH guidelines (Miller et al., 2013).

2.3.2. Food purchase measures—This task was conducted nearly identically to the protocol described in our manuscript and appendices on EFT and online shopping (Hollis-Hansen, Seidman, et al., 2019), except that participants were no longer constrained to a certain dollar amount while shopping. The online task was a measure included to see if the laboratory online grocery purchasing task used in a previous study (Hollis-Hansen et al., 2019) significantly correlates with the participant's real-world purchases (e.g. receipts). Baseline and follow-up receipts were analyzed using NutritionistPro (Stumbo, 2008), following the same procedures as previous studies to determine the dependent variables of calories and nutrients purchased (Hollis-Hansen, Seidman, et al., 2019; Hollis-Hansen et al., 2020). The primary variables of interest for the shopping purchases were created by dividing

the total calories and nutrients purchased by the number of people in the household. We also created a weighted score that took the age and caloric needs of the household members into account, however the weighted calorie and macronutrient data was strongly correlated with the data using raw family size as a denominator ($r(60) = 0.99$, $p < .001$) and did not change outcomes, therefore all analyses reported use the raw family size as the denominator to establish methodological consistency across EFT and food purchasing studies.

3. Analytic plan

3.1. Power analysis

Based on the effect size from the previous field study (Cohen's $f = 0.40$ or $\eta_p^2 = 0.13$) (Hollis-Hansen et al., 2020) we conducted an a priori power analysis that determined the present study would require 56 subjects or 14 subjects per group to achieve alpha of .05 and power of .80. Using dropout rates (1–10%) from previous studies with similar methods (Hollis-Hansen et al., 2020; O'Neil et al., 2015), we assumed 6 people were likely to dropout and recruited 62 subjects to ensure we would meet our required power.

3.2. Baseline differences

Between-group analysis of variance (ANOVAs, continuous variables) and chi-square tests (categorical variables) were used to identify any baseline differences in participant characteristics (Table 1).

3.3. Change in DASH diet adherence scores

Change in maternal adherence to the DASH diet was assessed using a linear mixed model with EFT and DASH education as dummy coded between-subjects' variables and pre- and post- DASH adherence scores as the repeated-measure variable. Baseline adherence scores were used as a covariate. Additional linear mixed models were planned to include variables that differed at baseline and correlated with the outcome of interest as additional covariates to confirm any observed effects and identify potential moderators.

3.4. Change in food receipts

To assess whether there were improvements in participant's food purchases, similar linear mixed models were used with calories or nutrients purchased at baseline and follow-up as the dependent variables. Baseline calories or nutrients were included as covariates in the separate models. We controlled for multiple comparisons using the Benjamini-Hochberg False Discovery Rate and adjusted p-values (Benjamini & Hochberg, 1995).

3.5. Change in AUC (DD task)

For change in AUC we used a linear mixed model with EFT and DASH as main effects and baseline and follow-up AUC as repeated measures dependent variables. Baseline AUC was included as a covariate in all models. Follow-up analyses were conducted with attention to cue and vividness as potential covariates and/or moderators of the EFT effect.

3.6. Validity of the online shopping task

Correlations and a simple linear regression model were used to examine whether the baseline laboratory purchasing task was a good predictor of calories and nutrients purchased in the natural environment (Cohen & Swerdlik, 2005). We also calculated the association between the amount of money spent in the online shopping task and the amount of money spent in the natural environment.

4. Results

4.1. Participant baseline differences

Participants differed on some baseline characteristics, including level of education ($F(3,56) = 2.98, p = .04$), baseline CFC scores ($F(3,56) = 3.18, p = .03$) and corner store shopping frequencies across groups ($F(3,56) = 4.07, p = .01$) (Table 1).

4.2. DASH adherence main effects and interactions

We observed a moderate size main effect of EFT on DASH diet adherence score ($F(1,56) = 4.51, p = .04, \eta_p^2 = 0.08$), but no main effect of DASH education ($F(1,56) = 2.78, p = .10$) and no interaction effect ($F(1,56) = 1.46, p = .23$) (Fig. 1).

4.3. Years of education as a covariate and moderator

Participant's education was the only variable that differed between groups at baseline that was also significantly correlated with DASH diet adherence score ($r = 0.31, p = .02$). Follow-up linear mixed models suggested that education had a strong effect on DASH diet adherence ($F(1,54) = 9.41, p < .01, \eta_p^2 = 0.15$). The EFT effect was still observed independent of education ($F(1,54) = 7.79, p < .01, \eta_p^2 = 0.13$), and education did not appear to moderate the EFT effect among our sample ($F(1,51) = 1.51, p = .22$).

4.4. Food purchasing main effects and interactions

There was a moderate main effect of EFT ($F(1,56) = 4.17, p = .05, \eta_p^2 = 0.07$), but no effect of DASH ($F(1,56) = 0.46, p = .50$) on milligrams of sodium purchased, and no significant interaction of EFT and DASH ($F(1,56) = 2.88, p = .10$). However, this effect was no longer significant after correcting for multiple comparisons (adjusted- $p = .25$). There was a trend toward moderate EFT effects on fat purchased ($F(1,56) = 3.69, p = .06, \eta_p^2 = 0.06$), but no effect of DASH ($F(1,56) = 1.40, p = .24$), and no significant interaction of EFT and DASH ($F(1,56) = 0.66, p = .42$). The fat trend was no longer approaching significance after controlling for multiple comparisons (adjusted- $p = .15$). There were no main effects or interactions on grams of protein, carbohydrates, or sugar purchased. There was no significant main effect of EFT ($F(1,56) = 2.68, p = .11$) or DASH ($F(1,56) = 0.90, p = .35$) on change in calories purchased from baseline to follow-up, and no significant interaction of EFT and DASH ($F(1,56) = 0.13, p = .72$).

4.5. Delay discounting main effects and interactions model

DD remained stable over time. There were no EFT ($F(1,55) = 0.25, p = .62$) or DASH ($F(1,55) = 0.06, p = .80$) effects on change in DD and no interaction ($F(1,55) = 0.69, p = .41$).

4.6. Delay discounting models with potential covariates and moderators

Follow-up models looked at number of cue recalls ($F(1,55) = 1.54, p = .22$), attention to cue ($F(1,55) = 0.18, p = .67$), and vividness ($F(1,55) = 0.62, p = .43$) as potential covariates and moderators, but none of the models were significant.

4.7. Validity of the online shopping task

The baseline receipts and the laboratory shopping task significantly correlated on calories purchased ($r(60) = 0.31, p = .01$), grams of fat purchased ($r(60) = 0.25, p = .05$), grams of carbohydrates purchased ($r(60) = 0.29, p = .02$), grams of protein purchased ($r(60) = 0.27, p = .04$), grams of saturated fat purchased ($r(60) = 0.42, p = .001$), milligrams of sodium purchased ($r(60) = 0.31, p = .02$), grams of fiber purchased ($r(60) = 0.43, p = .001$), and the amount of money spent by the participant ($r(60) = 0.60, p < .001$). The only nutrient that did not correlate was sugar ($r(60) = 0.17, p = .19$). The receipt mean for grams of sugar purchased was $590 \pm \text{SD} = 381$ while the task mean was slightly higher $613 \pm \text{SD} = 438$, though these means did not significantly differ ($t(60) = 0.31, p = .76$).

4.8. MAMRT (EMI tool) use and compliance

Smartphones were the devices most often used to complete cue recalls (89.5%) followed by computers (7.4%) and tablets (3.1%). Most recalls were completed at home (57.3%) or in a vehicle (15.3%). Some participants completed recalls at work (11.7%), at a food store or restaurant (8.7%), or at “other locations” (7.0%) which included responses such as “at a book store”, “at child’s school pick-up”, and “at the gym”. Participants rated their attention to their cues (Mean = $3.94 \pm \text{SD} = 1.12$) and the vividness with which they could picture their cues (Mean = $3.78 \pm \text{SD} = 1.10$) fairly high, which was consistent across groups (Table 1). Cue recalls ranged from 0 to 14, with an average of five recalls per person across the study period (Mean = $4.87 \pm \text{SD} = 2.67$). There were no differences in compliance by group ($F(3,56) = 0.76, p = .52$).

5. Discussion

The present study was designed to test ecological momentary EFT intervention over a one-week interval and low-touch DASH diet education on mothers’ eating behaviors and food purchases. Results from the 24-h food recall suggested greater improvements in DASH diet adherence for participants in the EFT groups than participants in the SET control groups, but no effect of DASH diet education. EFT was not associated with reliable changes in food shopping for the family for any of the dietary variables studied after controlling for multiple comparisons.

To study food purchasing behavior in the laboratory we previously developed a grocery purchasing task that asked participants to use a major retailers’ website to hypothetically

shop for one weeks' worth of groceries for their family (Hollis-Hansen et al., 2019). Participants were instructed on how to use the website and were then left to privately and freely make food and beverage choices by adding items to their cart. To establish validity of the laboratory task we developed, we asked participants to complete this task during the baseline appointment of the present study so that we could contrast baseline receipt data (e.g. real-world purchases) with selections in the laboratory shopping task. We found significant moderate to strong correlations between the receipt data and the lab task data, which suggests this task may be a good way for other researchers to pilot potential purchasing interventions in the laboratory.

While the current results extend the effects of EFT on dietary intake from one-time laboratory (Daniel et al., 2013) and field (O'Neill et al., 2016) studies to a weeklong ecological momentary intervention, we did not find that brief DASH education by itself helped participants make dietary choices that align with a healthier lifestyle. Our findings indicate a short video and handouts do not significantly influence eating behavior, which is consistent with previous research showing that knowledge of healthy choices may not be enough to effectively impact their own choices (McArthur, Valentino, & Holbert, 2017). Perhaps longer intervention with tailored education and daily feedback would improve the effectiveness of the DASH education component (Couch et al., 2008).

In previous studies we found significant EFT effects on several indices of mother's household food purchases (Hollis-Hansen et al., 2019, 2020). Over shorter intervals of food shopping it may have been easier for mothers to resist the temptation to buy higher calorie foods or find a way to shop independently and exert more influence over household food purchases. A longer period of shopping presents more opportunities for the mothers and their families to be faced with food purchasing choices and more instances where mothers may have to be amenable to their family's unique food preferences or household constraints.

Another methodological issue that may have influenced the null findings on calories purchased was the increased self-monitoring inherent in how participants were asked to track food purchases, such as recording and providing specific detail for every food item they purchased during the study period. These details included nutritional indicators (e.g. full-fat, low-fat, low sugar, low salt) and the quantity and size of each food item purchased. While this was needed to ensure we had complete and accurate nutritional data for analyses, it may have motivated participants to change their behavior regardless of their group assignment and may have been more powerful than the EFT effect. Self-monitoring has been found to be consistently effective at reducing weight and maintaining weight loss for adults (Burke, Wang, & Sevick, 2011) and it is an easier way to intervene than ever given the rise of digital self-monitoring tools (Patel, Hopkins, Brooks, & Bennett, 2019). While most studies have focused on having participants track the foods they consume, to our knowledge no studies have asked participants to track their food purchases. Future research could explore whether monitoring one's food purchases is as effective at improving eating behavior and food consumption as monitoring one's eating behaviors given that food purchasing is an antecedent of food consumption.

In the present study we tested an exploratory aim to examine if EFT training over a week would change DD without the presentation of EFT cues (Rung & Madden, 2019). This aim was unrelated to the primary and secondary hypotheses, as the other DV's were implemented with cues. In a recent study that tested longer EFT training (N = 50), EFT participants were randomized to complete cued or uncued DD tasks at six laboratory sessions over a three-month period (Mellis et al., 2019). Participants in the EFT-cued condition demonstrated reduced future discounting over time, while discounting among the EFT-uncued participants remained stable. The present study is now the fourth study to confirm that DD remains unchanged when participants complete the task without cues. This suggests that people without specific training on how to generalize EFT cues to default thinking need to be reminded to think about their future in the decision-making moment to see noticeable changes in discounting. Just-in-time adaptive interventions (JITAI) are designed to provide participants with tailored support in the moment via an EMI tool (Shani et al., 2019). Perhaps it is best to conceptualize EFT as a JITAI until long-term studies can confirm how and for whom EFT may become habitual. Research should explore EMI's that include a machine learning component that could identify the participant's triggers and provide cues at the "right time" for the participant and their family.

The failure to test effects of EFT on DD by providing EFT cues during the discounting task is a major limitation. The absence of an EFT effect on uncued DD suggests that prospective thinking did not become a default approach to temporal decision making over one-week. It is possible that during food preparation and consumption mothers recalled their cues, which impacted their eating, but there may be other reasons why eating changed more for the EFT participants than the SET participants. One possibility is greater demand characteristics for EFT than recent thinking or diet education (Rung & Madden, 2018). However, despite the fact that participants in EFT studies may intuit the researcher's intentions (Rung & Madden, 2018b; Stein, Tegge, Turner, & Bickel, 2018), controlling for demand characteristics does not seem to account for the effects of EFT (Rung & Madden, 2019; Stein et al., 2018). Further, if effects were only owed to demand characteristics, it is unclear why there would be no demand expectancies for the DASH nutrition education or the other dependent measures (e.g. food purchases), given that the study was advertised to the public as "The Supermarket Selections Study".

A limitation of this study is the sample size. As EFT is the primary interest of this body of work, this study was powered using a between-subjects EFT effect size. Research suggests that educational videos produce small health behavior changes about half of the time (Tuong, Larsen, & Armstrong, 2014) and that tailored video education with interactive components are the most effective (Abu Abed, Himmel, Vormfelde, & Koschack, 2014). While no meta-analyses have been conducted and therefore no clear effect size is available on brief video dietary education and educational tip sheets, we were likely underpowered to observe a between-subjects DASH diet education effect. In addition, the majority of studies on using EFT to improve eating behaviors (Daniel et al., 2013; Dassen et al., 2016) or shopping behaviors (Hollis-Hansen, Seidman, et al., 2019) are shorter laboratory studies, and the effect sizes for more extended repeated measures studies on dietary adherence and shopping are unknown. Given that smaller samples may overestimate effect sizes (Button et al., 2013), it is possible that a more conservative effect size and a larger sample size would

have shown different results for the food purchases, as the sodium was no longer significant and the fat was no longer trending towards significance after controlling for multiple comparisons.

This study focused on mothers with overweight and obesity that indicated they were interested in buying healthier food for their families, therefore this intervention may not generalize to the general population or to those who are uninterested in changing their behavior. Previous researchers have shown that the food people buy for themselves or for their household correlates with their eating habits (Appelhans, French, Tangney, Powell, & Wang, 2017; Eyles, Jiang, & Mhurchu, 2010) and in this pilot, parent's food purchases are used as a proxy measure of the household food environment, but this outcome provides no information about what other members of the household actually consumed. It is possible that while the food was purchased, it wasn't eaten within the study period or by all members of the household. Future research should seek to intervene with and obtain food recall data for everyone residing in the home.

Researchers have identified numerous individual and household factors that influence food procurement, and therefore food consumption, such as each family member's individual taste preferences, family structure (e.g. one vs. two parent households, number of children), parenting style, parent's employment status, time scarcity, financial scarcity, cultural preferences, personal transportation, parent's knowledge, skills, abilities, and more (Caswell & Yaktine, 2013). While EFT may address some of the behavioral motivations of food choice and food consumption making it easier for one person to make better choices for themselves, perhaps more research could be done to help parents more effectively parent around food shopping and eating behavior. Prior studies have identified that mothers feel "a perceived loss of parental control, the inability to establish rules, and the failure to consistently enforce those rules" (Ruiter et al., 2019) when attempting to make healthier food choices for their families. Therefore, focusing not just on parenting practices (e.g. context and goal-specific behaviors or interactions) such as food shopping, but on general parenting style (e.g. attitudes and broader parenting patterns) and family functioning may help mothers to establish a healthier relationship around food and food purchases (Kitzmann & Beech, 2006).

The present study, along with our previous work on the use of EFT to improve shopping behavior has focused on the independent effects of EFT. EFT can also be implemented as a complement to a traditional behavioral weight control program that could focus EFT not only on resisting the temptation to eat high energy dense nutrient poor foods, but also on improving shopping to modify the shared family food environment. Additionally, results from prior studies suggest that asking participants to imagine a past or future *meal* may help them to reduce food intake in the present (Vartanian, Chen, Reily, Castel, 2016). Future studies could include a food intake or food purchasing memory or future simulation in addition to general EFT to see if doing so would be more powerful over a longer study period. More research should be done to determine the potential influence of demand characteristics in EFT studies, what drives EFT effects, how we can better implement EFT as a useful component to family-based treatment programs, and how to effectively extend EFT effects to other members of the family, such as spouses and children.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Ethical statement

This study was approved by the University at Buffalo Social and Behavioral Sciences Institutional Review Board (#STUDY00003260). All participants gave informed consent before taking part in the research. This research was funded in part by a grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development [R01 HD080292-02] and a grant from the Mark Diamond Research Fund at the University at Buffalo [SP-19-11]. The funders were not involved in analysis or interpretation of the data.

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Fig. 1. Change in maternal DASH diet scores (mean $\pm$ SEM) by group from baseline to follow-up controlling for baseline variability. DASH scores were computed using Dixon's algorithm (Dixon et al., 2007) whereby a higher total score indicates greater adherence to the DASH diet guidelines.

Table 1:

Participant and study characteristics.

	EFT + DASH n = 15	EFT + SAFETY n = 15	SET + DASH n = 15	SET + SAFETY n = 15	p-value
Baseline Characteristics					
<i>Age (Mean ± SD, years)</i>	37.80 ± 3.59	40.20 ± 5.66	38.93 ± 7.24	39.87 ± 5.96	.67
<i>Income (Mean ± SD, \$, thousands)</i>	52 ± 36	92 ± 64	88 ± 45	111 ± 181	.45
<i>Subjective Social Status (Mean ± SD)</i>	5.07 ± 1.79	4.60 ± 1.57	5.33 ± 1.33	4.67 ± 1.42	.52
<i>Cash Assistance (n, %)</i>					
Yes	3 (20.0%)	4 (26.7%)	3 (20.0%)	5 (33.3%)	.98
<i>Food Insecurity (Mean ± SD)</i>	0.67 ± 1.23	0.93 ± 1.79	0.80 ± 1.70	1.13 ± 1.60	.69
<i>Education (Mean ± SD, years)</i>	14.40 ± 2.35	16.53 ± 2.00	16.07 ± 2.15	16.33 ± 2.23	.04*
<i>Body Mass Index (Mean ± SD)^b</i>	31.53 ± 5.71	31.60 ± 4.16	36.24 ± 6.21	33.39 ± 6.56	.10
<i>Family Size (Mean ± SD, people)</i>	3.87 ± 1.46	4.20 ± 1.15	4.27 ± 1.10	4.07 ± 0.88	.79
<i>Race (n, %)</i>					
White	9 (60.0%)	11 (73.3%)	13 (86.7%)	11 (73.3%)	
People of color	6 (40.0%)	4 (26.7%)	2 (13.3%)	4 (26.7%)	.42
<i>Baseline AUC (Mean ± SD)^a</i>	0.31 ± 0.18	0.33 ± 0.30	0.43 ± 0.27	0.35 ± 0.27	.62
<i>CFC Score (Mean ± SD)</i>	5.16 ± 0.78	5.34 ± 0.77	5.03 ± 0.89	4.47 ± 0.80	.03*
<i>Perceived Stress Score (Mean ± SD)</i>					
<i>Shopping Frequency (Mean ± SD)</i>					
Supermarket	4.07 ± 1.10	4.33 ± 0.61	4.07 ± 0.96	4.47 ± 0.74	.51
Supercenter	2.00 ± 1.73	2.53 ± 1.92	1.67 ± 1.45	1.53 ± 1.73	.39
Cornerstore	0.80 ± 1.32	3.00 ± 2.07	2.13 ± 1.69	1.93 ± 1.79	.01*
Specialty Store	0.80 ± 1.26	0.60 ± 0.74	1.40 ± 1.40	0.93 ± 1.22	.31
Farmer's Market	1.33 ± 1.59	1.00 ± 1.00	1.00 ± 1.01	1.53 ± 1.51	.62
Pantry	0.00 ± 0.00	0.47 ± 1.25	0.07 ± 0.26	0.07 ± 0.26	.20
Home delivery	0.27 ± 1.03	0.27 ± 0.80	0.60 ± 1.35	0.73 ± 1.44	.62
Co-op	0.53 ± 1.46	0.40 ± 1.30	0.27 ± 0.70	0.40 ± 0.83	.93
<i>Eating Habits (Mean ± SD, svgs/week)</i>					

	EFT + DASH n = 15	EFT + SAFETY n = 15	SET + DASH n = 15	SET + SAFETY n = 15	p-value
Fruit	3.87 ± 2.17	5.33 ± 2.02	4.20 ± 2.08	4.53 ± 1.73	.23
Green Vegetables	3.47 ± 2.41	3.87 ± 1.64	3.8 ± 1.57	3.53 ± 2.30	.93
Fried Potatoes	1.40 ± 1.35	1.47 ± 1.30	1.33 ± 1.80	2.40 ± 2.10	.26
Other Potatoes	2.13 ± 1.41	1.87 ± 1.51	1.87 ± 1.77	1.87 ± 1.19	.95
Other Vegetables	5.07 ± 2.05	4.80 ± 2.24	4.33 ± 1.63	5.07 ± 2.05	.72
Fast Food	2.00 ± 1.81	2.53 ± 3.23	3.87 ± 3.07	2.20 ± 1.42	.18
Restaurant Food	0.93 ± 1.39	1.80 ± 1.74	2.00 ± 2.45	1.00 ± 0.85	.22
DASH Score (Mean ± SD) ^b	3.23 ± 0.80	2.93 ± 1.05	3.27 ± 1.12	2.97 ± 0.99	.71
Total Spent (Mean ± SD, \$) ^b	200.55 ± 83.34	155.58 ± 85.06	173.88 ± 323.90	174.36 ± 107.60	.77
Calories Purchased (Mean ± SD) ^b	14,434 ± 9001	9982 ± 6391	9082 ± 2330	13,824 ± 7670	.08
Reporting of Purchases (n, %) ^b					
< 7000 calories per person per week	2 (13.3%)	6 (40.0%)	4 (26.7%)	4 (26.7%)	
7000 calories per person per week	13 (86.7%)	9 (60.0%)	11 (73.3%)	11 (73.3%)	.42
Study Characteristics Time between appt (Mean days ± SD)	7.87 ± 2.33	7.07 ± 0.46	7.47 ± 0.74	8.07 ± 2.63	.45
EMI cue measures (Mean ± SD)					
Number of cue recalls	4.33 ± 2.29	5.73 ± 3.06	4.67 ± 2.47	4.73 ± 2.84	.52
Attention to cues	4.14 ± 1.30	4.01 ± 0.65	4.22 ± 0.84	3.96 ± 0.55	.84
Vividness of cues	3.83 ± 1.31	3.82 ± 0.67	3.89 ± 0.66	4.10 ± 0.70	.80
AUC (Mean ± SD) ^{a,c}	0.37 ± 0.28	0.36 ± 0.28	0.40 ± 0.34	0.39 ± 0.33	.98
DASH Score (Mean ± SD) ^c	3.70 ± 1.00	3.77 ± 1.08	2.83 ± 1.06	3.53 ± 0.95	.06
Lab Task Total Spent (Mean ± SD, \$)	138.59 ± 107.04	158.15 ± 84.60	172.42 ± 62.16	169.04 ± 89.76	.71
Total Spent (Mean ± SD, \$) ^c	138.54 ± 81.71	127.59 ± 61.58	188.85 ± 76.80	164.85 ± 107.61	.20
Calories Purchased (Mean ± SD) ^c	10,098 ± 4680	8129 ± 3810	11,899 ± 8561	11,019 ± 6456	.39
Reporting of Purchases (n, %) ^c					
< 7000 calories per person per week	4 (26.7%)	7 (46.7%)	2 (13.3%)	4 (26.7%)	
7000 calories per person per week	11 (73.3%)	8 (53.3%)	13 (86.7%)	11 (73.3%)	.24
Body Mass Index (Mean ± SD) ^c	31.47 ± 5.55	31.50 ± 4.14	36.34 ± 6.23	33.42 ± 6.62	.08

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AUC stands for “area under the curve”, which is used as a measure of delay discounting, a higher AUC (e.g. closer to 1) suggests less discounting of the future outcome while a lower AUC (e.g. closer to 0) suggests greater discounting of the future outcome; All p-values are derived from between-group ANOVAs (continuous variables) and chi-square tests (categorical variables).

q Indicates a baseline measure.
 c Indicates a follow-up measure.