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Sweetened Drink and Snacking Cues in Adolescents: A Study Using Ecological Momentary Assessment

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Word Count: 7,235

Tables: 5

Figures: 0

Abstract

The objective of this study was to identify physical, social, and intrapersonal cues that were associated with the consumption of sweetened beverages and sweet and salty snacks among adolescents from lower SES neighborhoods. Students were recruited from high schools with a minimum level of 25% free or reduced cost lunches. Using Ecological Momentary Assessment, participants (*N*=158) were trained to answer brief questionnaires on handheld PDA devices: (a) each time they ate or drank, (b) when prompted randomly, and (c) once each evening. Data were collected over 7 days for each participant. Participants reported their location (e.g., school grounds, home), mood, social environment, activities (e.g., watching TV, texting), cravings, food cues (e.g., saw a snack), and food choices. Results showed that having unhealthy snacks or sweet drinks among adolescents was associated with being at school, being with friends, feeling lonely or bored, craving a drink or snack, and being exposed to food cues. Surprisingly, sweet drink consumption was associated with exercising. Watching TV was associated with consuming sweet snacks but not with salty snacks or sweet drinks. These findings identify important environmental and intrapersonal cues to poor snacking choices that may be applied to interventions designed to disrupt these food-related, cue-behavior linked habits.

Key words: adolescents, diet, food habits, cues, Ecological Momentary Assessment

Introduction

The proportion of adolescents in the US who are overweight or obese is a critical public health concern (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). Nationwide, the prevalence of being overweight and obese (BMI $\geq$ 85 percentile) is 34.2% among all adolescents 12-19 years of age (Ogden et al., 2010). The prevalence of obesity is especially high among lower income families. In California, where this study was conducted, teens 12-17 years of age from lower income families (<300% Federal Poverty Level) are at elevated levels of risk of being overweight (20.7%) or obese (15.4%) compared to teens from higher income families (>300% FPL: 11.8% overweight and 7.5% obese) according to the California Health Interview Survey (California Health Interview Survey, 2012). Adolescents with high BMI are at increased risk for chronic diseases including cardiovascular disease and type 2 diabetes mellitus among others (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Knight, 2011).

Obesity is, of course, closely related to diet (Baranowski et al., 2000; Goran, 2001; Hill, Melanson, & Wyatt, 2000; Mendlein, Baranowski, & Pratt, 2000), including snacking and sweetened beverage consumption. Evidence is accumulating that consumption of sugar-sweetened beverages is linked to increased body weight (Malik, Schulze, & Hu, 2006) and increased risk of medical problems including diabetes (Centers for Disease Control and Prevention (CDC), 2011; Malik et al., 2010; Vartanian, Schwartz, & Brownell, 2007). In addition, there is evidence that excess consumption of energy-dense snack foods is associated with an unhealthy weight gain (Piernas & Popkin, 2011; Swinburn, Caterson, Seidell, & James, 2004). The current study uses real-world, real-time data collected via Ecological Momentary Assessment (EMA: (Shiffman, 2009; Stone & Shiffman, 1994)) techniques to identify environmental and intrapersonal cues associated with habitual consumption of high calorie snacks and sweetened beverages.

Over time, some dietary behaviors may evolve through learning into habits that are initiated by situational cues (stimulus-driven habits). Research in neuroscience (Knowlton,

Mangels, & Squire, 1996; Yin & Knowlton, 2006a; Yin & Knowlton, 2006b), memory (Nelson & Goodmon, 2003), social psychology (Bargh & Williams, 2006; Dijksterhuis, Smith, van Baaren, & Wigboldus, 2005), and research on appetitive behavior (LaBar et al., 2001) have consistently shown the importance of cues in spontaneously triggering habits and related cognitions. A situation such as a location, social setting, or mood may become a cue for a behavior after repeated co-occurrence with that behavior, especially when the behavior has immediate rewards such as consumption of palatable foods. A friend, for example, may not be associated with having a snack initially, but after repeatedly meeting the friend after school to buy chips and a soda, the sight of the friend may become a cue for the behavior. The current study was especially interested in stimulus-response (S-R) habits formed by this type of instrumental learning that may be highly resistant to modification (Yin & Knowlton, 2006b). After a strong (S-R) habit is formed, the cue (stimulus) can initiate the behavior (response) regardless of anticipated outcomes (Wood & Neal, 2007; Yin & Knowlton, 2006a). The habit is likely to persist even after the outcome contingency has changed (i.e., negative consequences are encountered due to excessive weight gain) and despite learning new facts about obesity (e.g., through traditional education). Habit is supported by neural systems that reflect a set of processes classified as procedural memory, which is independent from declarative or explicit memory (e.g., memory for new facts through education), as documented in a series of studies on multiple brain systems (Knowlton et al., 1996; Ryan & Cohen, 2003). Frameworks incorporating these findings and non-declarative processes have been increasingly applied to a range of appetitive behaviors (for recent reviews, see (Stacy & Wiers, 2010; Stacy, Ames, Wiers, & Krank, 2010)). Poor dietary habits that are allowed to continue unchecked can lead to a lifetime struggle with obesity and related chronic diseases. It is vitally important therefore to identify cues that trigger maladaptive dietary habits to facilitate the design of interventions that will disrupt the cue-behavior link and encourage healthy diets.

Participants may not be aware of the cues that trigger their habits (Dijksterhuis et al., 2005; Knowlton et al., 1996; Wood & Neal, 2007). Self-reports on the causes of behavior may not fully reflect the cue-habit process (Bargh, 2005; Dijksterhuis et al., 2005), and this makes it difficult to assess the cue-habit link with traditional surveys where participants are asked to introspect about their behavior in the previous days or months. It is possible that assessing behavior in real time may better identify cue-behavior patterns that are not captured by conventional, retrospective questionnaires (Shiffman, 1993; Shiffman, Stone, & Hufford, 2008). Real time assessment may be particularly helpful in identifying these linkages if the procedures simply record cue and behavior co-occurrences, facilitating the study of their empirical linkages without requiring participant awareness of the link.

EMA (Shiffman et al., 2008) is an assessment technique with several key features: (a) participants respond to questions during their typical activities in the real-world environment, which permits researchers to generalize the findings to the real lives of the participants, (b) responses of the participants focus on their current situation, activities, and feelings, which can eliminate recall bias associated with assessments that ask for recall of events over longer periods of time, (c) questions are asked at strategically selected times to capture situations, activities, and feelings during target events such as eating and, for purposes of comparison, during random times when participants may not be doing the target activity (i.e., non-eating situations), and (d) data are typically collected multiple times in a day and over several days to capture how behavior changes across situations and to accumulate multiple instances of the events of interest. The design and technology may differ by study question and behavior, but all EMA studies collect data repeatedly from participants on their current state or situation in their natural environment. Researchers then may examine how situations, activities, and feeling states influence the behavior of interest.

EMA has been widely used over a period of more than 20 years to measure health behaviors and antecedents related to smoking (Shiffman, 2005), exercise (Dunton, Whalen,

Jamner, & Floro, 2007; Gorely, Marshall, Biddle, & Cameron, 2007; Hausenblas, Gauvin, Downs, & Duley, 2008), and diet (Glanz & Murphy, 2007; Greeno, Wing, & Shiffman, 2000; le Grange, Gorin, Catley, & Stone, 2001), with considerable evidence supporting its validity and utility among adults and youth. EMA procedures have shown less recall bias than retrospective questionnaires among adolescents and children as young as 7 years (van den Brink, Bandell-Hoekstra, & Abu-Saad, 2001), and previous EMA studies among children and adolescents include, for example, physical activity (Dunton et al., 2007; Dunton, Liao, Intille, Spruijt-Metz, & Pentz, 2011) smoking cessation (Gwaltney, Bartolomei, Colby, & Kahler, 2008), and mood (Weinstein & Mermelstein, 2007; Weinstein, Mermelstein, Hankin, Hedeker, & Flay, 2007). Prior EMA studies have successfully examined dietary behavior but largely among participants recruited from obese populations and/or those with eating disorders (Engel et al., 2009; Greeno et al., 2000; Hilbert & Tuschen-Caffier, 2007; Smyth et al., 2009).

The objective of the current study was to empirically identify situations or cues associated with unhealthy snacking and sugar-sweetened beverage consumption among participants recruited from public high schools in lower SES neighborhoods. We anticipated that, although the development of habits is likely to be idiosyncratic, common life experiences across participants would result in some common cue-behavior associations that can be identified using EMA. We also anticipated that multiple situations may cue snacking behaviors and that some of those situations might be related but not co-occurring. We reasoned, for example, that development of a habitual response to one cue (e.g., feeling happy) would not necessarily exclude the development of the same habitual response to a related cue (e.g., feeling sad). The analyses contrasted situational factors associated with consumption of these unhealthy drinks and snacks with those associated with non-sweetened drinks, healthy snacks, meals, and non-eating or drinking occasions. The study focused on cues associated with the consumption of sugar-sweetened drinks, sweet snacks, and salty snacks, which are associated with weight gain and related medical problems (Carels et al., 2001; Centers for Disease Control

and Prevention (CDC), 2011; Malik et al., 2010; Piernas & Popkin, 2011; Vartanian et al., 2007). In addition, consumption of these food items is more likely to be under the control of adolescents, compared to meals prepared by adults in the home, making sweetened drinks and energy dense snacks ideal targets for behavioral interventions among adolescents.

Methods

Participants

Participants were recruited from high schools that met the following criteria: (a) minimum of 25% of students in a free or reduced price meal program, (b) minimum of 25% Hispanic students, (c) maximum of 25% Asian students, (d) minimum enrollment of 100, (e) included students between 14 and 17 years of age, and (f) were within 30 miles of the assessment site in San Dimas, CA. The intention was to recruit a sample of students from lower income families at elevated risk of being overweight or obese for whom improved interventions may be especially beneficial. Lower income populations have fewer interventions developed on their behalf, and we wanted to target this underserved group. Schools were excluded if they were classified as adult education, alternative, charter, continuation, community, or special education schools. Flyers were distributed during lunch periods or at other times approved by those schools that met the criteria and approved onsite recruitment. Flyers briefly described the study objectives, participant activities (see procedure below), and the compensation for participating. Recruiters collected contact information on site from students expressing interest in participating, and then called the parents to assess eligibility and schedule a baseline appointment.

Students were eligible to participate if they were: (a) 14 to 17 years old, (b) able to speak and write English, (c) free of major illness, (d) not currently receiving treatment for obesity, and (e) able to travel to the assessment site with a parent or guardian. Only one child was eligible from each family, and no more than 15 students were recruited from each school. Spanish speaking recruiters and data collectors were available to parents who only spoke Spanish.

Approximately 3,000 flyers were distributed, and 1,423 students expressed interest in the study. The parents of these students were then randomly selected from within each school and invited by phone to participate in the study. In total, 251 families were screened by telephone for eligibility (recruiters stopped screening students when the target number of participants was met), 243 were scheduled for an appointment to be assessed and receive training on the PDAs. Of those, 158 participants (65.02%) representing 13 schools attended the appointments and completed the EMA protocol. Participants included 90 (57.0%) females (see Table 1). Self-reported ethnicity included 67.7% Hispanic/Latinos, 4.4% African American, 2.5% Asian, 5.1% White, 2.5% Native American, 15.8% mixed, and 1.1% other or missing. Parent education level is one proxy measure for family SES, and approximately half of the participant's parents did not finish high school. Sixty percent of the participants resided with both parents. A high percentage of participants were obese (25%) compared to results from the Youth Risk Behavior Surveillance System. In Los Angeles County in 2011, 13% of all high school students were obese and 15% of Hispanic students were obese (CDC, 2012).

< Insert Table 1 about here>

Procedures

Each participant and a parent or guardian came to a university facility for assessment and training prior to beginning the EMA protocol. During this session, parents read and signed a consent form, and participants signed an assent form after reviewing the forms with trained research assistants. The forms were available in Spanish for parents as needed. After obtaining consent and assent to proceed, data collectors guided participants through a series of baseline measurement and training tasks: (a) individual measurement of height and weight by research staff data collectors, (b) individual training on the PDA, (c) one-to-one interviews with data collectors regarding snacking and afterschool activities, and (d) assessment of baseline characteristics using self-report, computer-based questionnaires and tasks. A standardized procedure was used to train participants on how to operate the PDA and how to place the

device in the cradle for charging and data transfer. Participants practiced entering data on the PDA and setting up the cradle for charging and data transfer during the training sessions at the university facility.

Baseline Assessment. Participants completed a series of assessments at the university facility after receiving the EMA training. Baseline assessments included weight, height, a brief interview, and self-administered questionnaires taken on laptop computers (demographics, eating behaviors, and family relationships). The current report focuses exclusively on assessments collected using EMA techniques and those procedures and measures are described below.

EMA Procedures

As described in the introduction, EMA procedures permit the assessment of behaviors as participants go about their normal daily activities. This is critical to identify links between situations and behaviors of which the participants themselves may not be aware (Dijksterhuis et al., 2005). EMA software was developed to the project's specifications (invivodata, Inc., Pittsburgh, PA), and implemented on Palm E2 PCA devices, along with a wireless Enfora modem (Novatel Wireless, Richardson, TX). Data were transferred automatically to a central server at the end of each day when a participant placed the PDA in the wireless modem/recharging cradle. The systems were thoroughly tested, and software and assessments were piloted with participants.

Participants were told that the current training day (day1) and the next day (day 2) could be used to practice using the device and that the following 7 days (days 3-9) would be the critical test days. Before leaving the facility, parents were briefly introduced to the PDA device and data collectors emphasized the importance for the student of following the EMA protocol as instructed. Compensation for the time required of the participant to attend the training session and complete the EMA protocol was $200, and it was sent to each participant after the device was returned.

Eating Event Reports. During the 7-day monitoring period participants were instructed to complete assessments on their PDAs on three types of occasions: eating events, random prompts, and evening reports. For the eating events, participants were instructed to record each food or drink they consumed within 15 minutes after consumption. A drink was defined as any time the participant drank any liquid such as water, juice, milk, or soda; a meal was defined as eating at a time that the participant considered to be breakfast, lunch, or dinner; and a snack was defined as eating at a time that the participant *did not* consider to be breakfast, lunch, or dinner. Participants were also provided with a worksheet (available from the authors) to help them categorize on the PDA the types of food and drinks they consumed. The worksheet listed types of foods that participants would select from on the PDA: (a) snacks, (b) fruits/vegetables, (c) carbohydrates, (d) protein, and (e) drinks. For each food type, the sub-categories were also listed as they appeared on the PDA after a participant selected a food type. If a participant selected protein, for example, the following sub-categories would appear: Chicken/pork/beef, beans/nuts, dairy, fish, and eggs/tofu. The worksheet also provided examples for each PDA sub-category (e.g., for chicken/pork/beef: chicken nuggets, hamburger, hot dog, taco), but these examples did not appear on the PDA. Participants used these examples to guide selection of food categories when they entered data on the foods they consumed into the PDA device. Participants did not record eating events that occurred during school hours (i.e., 8am to 3pm on school days); schools were unwilling to have students interact with the EMA devices during school hours.

Random Prompt Reports. In addition to recordings that participants self-initiated on the PDA for eating events, the PDA prompted participants at random times during the day to complete a similar set of questions at the time the PDA alarm went off – this was called a random prompt. The questions were equivalent to those asked in the eating event report. On school days, one random prompt was issued between 3 and 6pm and one between 6 and 9 pm,

whereas on non-school days 4 prompts were issued, one each in the following 3-hour intervals: 9am-noon, noon-3pm, 3pm-6pm, and 6pm-9pm.

Evening Reports. Finally, at the end of each day, participants were instructed to complete an evening report between 6pm and 11:45pm to assess their level of stress and the availability of food in the home throughout the day. An alarm on the PDA went off if a participant had not entered the evening report by 8pm and a second alarm occurred at 9pm.

Compliance. A specific procedure was followed by data collectors to promote compliance with the EMA protocol among the participants. Trained coordinators/data collectors monitored daily the incoming EMA data from each participant, and participants had the opportunity to call the coordinators if any problems or questions arose. Monitoring was supported by a website where coordinators could review summaries of participants' entries and compliance. Participants were contacted by phone to promote compliance if any of the following occurred: (a) they missed data transfer in the evening, (b) they reported less than three eating/drinking events on the previous day, (c) they missed more than two random prompts in the past two days, or (d) they missed the two most recent evening reports. PDA coordinators reported and tracked all communication with study participants on a secure online data management system.

Eating and Random Event Measures

Momentary assessments in response to eating events and random prompts were completed on the PDA, which displayed one question at a time on the screen. The EMA items were selected partially based on information collected from focus groups with adolescents to learn about their eating patterns, with a special focus on snacking (locations, social environment, types of snacks and drinks, etc.), mood scales, and food-related cues such as the sight or smell of food identified in studies on restrained eating (Coelho, Polivy, Herman, & Pliner, 2008; Fedoroff, Polivy, & Herman, 2003; Polivy, Herman, & Coelho, 2008). The random prompts and eating event assessments consisted of questions about participants' location,

social environment, mood, and food-related behaviors. The random prompt assessment included an item in the beginning asking participants if they were eating or drinking anything, with a binary response option “yes”/“no.” If the response was “yes,” they were asked what they were consuming: (1) drink only, (2) snack with or without a drink, and (3) meal with or without a drink. The self-initiated eating event report asked participants what they had just consumed with the same three response options. The random event and eating event assessments were otherwise identical in content. The following paragraphs describe the questions assessed on the PDA.

Location. Participants reported on their physical location just before they began eating (“Where were you just before eating/drinking?”), first choosing between general location (e.g., home, school, store, etc.), and then providing more details about their immediate location within the broader categories. The report was completed after eating per instructions during training, and the report might not have occurred in the same location as the eating event. The situations encountered just before eating were important to consider as potential cues to eating behaviors. Each of the following situations was assessed in a similar manner.

Social Setting. Participants responded to two questions asking if they were alone (yes or no), and if not alone, whom they were with just before eating.

Family Influence. Participants were asked three questions about the context of their eating, including what happened just before they ate or drank and family members they were with just before eating. This scale also included questions about family influence over adolescents’ food behaviors such as, *“Criticized by family member about what you were eating?”*

Current Mood. Thirteen items about participants’ emotional states were adapted from the Daily Affect Scale previously used in EMA data collection with adolescents (Weinstein & Mermelstein, 2007; Weinstein et al., 2007), which included mood adjectives such as tired, stressed, relaxed, cheerful, etc., rated on a sliding scale ranging from 0 to 100 and anchored at

"Not and all" to "Very much." Factor analyses on the data (principal components with varimax rotation) was consistent with the four-factor structure reported by Weinstein and colleagues: 1) Positive Affect (Happy, Relaxed, Cheerful, Energetic, alpha=.72); 2) Negative Affect (Lonely, Embarrassed, Sad, Angry, Left-Out, alpha=.79); 3) Stressed/Frustrated (Frustrated and Stressed, alpha=.76); and 4) Tired/Bored (Tired, Bored, alpha=.41). The four subscales were created by taking the average of the items (Scale remains on a 0 – 100 scale).

Activities. Participants were asked what they were doing at the moment, and response options included *"using electronic media", "coming from school", "working", "hanging with friends", "sleeping", "exercising", "studying/reading*", and "*other activity*". If participants answered *"using electronic media*", they were asked more detailed questions about the type of media they were using: *"watching TV", "computer/video games", "working on a computer", "IM/email on computer", "texting", "listening to music"*, and *"other".*

Appetite/Craving. Questions about participants' food and drink cravings were adapted from Greeno, Wing and Shiffman (2000) (Greeno et al., 2000). Participants responded to the question "What were you craving?" for each of the following categories: *sweet snack, salty snack, sweetened drink, non-sweetened drink, fruit/vegetables*, and *meal*. Response options were "yes" or "no" for each category.

Binge Eating. Binge eating episodes were assessed using two items from the Binge-Eating Disorder Subscale of the Eating Disorder Diagnostic Scale (Sierra-Baigrie, Lemos-Giráldez, & Fonseca-Pedrero, 2009; Stice, Telch, & Rizvi, 2000).

Food Consumption. A detailed assessment of food consumption asked participants what they were eating or drinking and listed detailed items as response options, including lists of drinks, snacks, fruit/vegetables, carbohydrates, protein, and meat from which participants could select the type of food they had just consumed. The items included healthy as well as unhealthy items. In the current analyses, we contrast situational correlates of sweetened drink and snack consumption to other situations, which might include consumption of healthy items. Some of

the drink and snack items were grouped together to create three new binary variables: (1) consumption of sweetened beverages, (2) consumption of sweet snacks, and (3) consumption of salty snacks. These served as the main dependent/outcome variables in our analyses (see Table 2 for a list of target drinks and foods).

< Insert Table 2 here >

Evening Report Measures

The evening report (items not shown) assessed events or situations that might change daily but not on an hour to hour basis, including items about stress level and food availability in the home.

Stress. Each evening assessment asked participants to report on their stress level. Cohen's Perceived Stress Scale was used for this assessment (Cohen, Kamarck, & Mermelstein, 1983). This 7-item scale has been previously used in EMA studies and shown to be reliable (Shiffman & Waters, 2004). Three additional items asked about good and bad events during the day: "*Did you have a good/bad thing happen today?*", "*Was it related to: parent, sibling, friend, other person, job, school, other?*" and "*How good/bad was this event?*"

Food Availability. Participants completed a 12-item measure of daily food availability asking them *"What snacks or drinks were available to you in your home today?"* with seven items about drinks (bottled/vitamin water, fruit juice, soda, diet soda, sport/energy drink, dairy/soy milk, and none of the above), and five items about snacks (fruit/vegetables, cereal/granola bars, chips/pretzels/crackers, cookies/pastries/candy, and none of the above). The response options were binary (yes/no).

Exercise. Participants answered the following question (yes or no) taken from the Patient-Centered Assessment and Counseling for Exercised Plus Nutrition screening measure (Prochaska, Sallis, & Long, 2001) to assess their physical activity that day "*Were you physically active for a total of at least 60 minutes today?"*

Analysis

The analytic dataset included the combined self-initiated, momentary eating event reports (drinks, snacks, and meals) and all momentary random event reports including events where participants were not eating at the time of the prompt and events where they were eating by chance at the time of the random prompt. In addition, evening report data were linked to the momentary observations.

Univariate regressions identified which of the EMA cues were significantly associated with each of the following outcome variables: (a) sweetened drink consumption, (b) sweet snack consumption, and (c) salty snack consumption. These binary outcome variables contrasted target outcome events against all other events including consumption of non-sweetened drinks, healthy snacks, and meals as well as random prompt events where drinks or food were not being consumed. Meals were not considered snacks even if a sweet drink, sweet snack, or salty snack was consumed as part of the meal.

The odds ratios were estimated using a SAS (Version 9.2) Proc Glimmix Multilevel Model where momentary observations were the Level 1 variables and persons/participants were the Level 2 variables. Within person odds ratios were estimated by first group mean centering (i.e. centering within person) each potential cue and then running a multilevel logistic equation with one cue variable. The resulting odds ratios represented the increase in odds for a unit change in the value of the cue variable. For example, the binary cue variable, “home”, (assigned a value “1”) would be contrasted to all other response options (“0”). For continuous cue variables, the odds ratios represented the change in odds due to a change of one standard deviation in the cue value. The odds ratios are a measure of the effect size for the association between the cue and outcome (Ellis, 2010). Relatively large odds ratios were expected to be suggestive of cue-behavior (S-R) habits. As this was regarded as an exploratory analysis and the first of its kind in the field, we did not correct for multiplicity.

Multiple logistic regression models included cue variables that were significant (OR>1.0) and non-redundant in the univariate models. Only those cues that were suggestive of cue-behavior (S-R) habits for consuming more sweet drinks or snacks (OR>1.0) were included to address the research question in the current study. Separate models were fit to the data for each target outcome including sweet drinks, sweet snacks, and salty snacks. The models were used to determine whether the cues were independent predictors providing additional evidence suggestive of S-R habits.

Results

Assessments and compliance

Participants (n=158) were monitored for an average of 6.70 (SD=0.25) days; 98.73% were monitored for the full 7 days. A total of 3992 momentary assessments were recorded: 1868 random prompts (1.69 per participant day), 2124 eating event reports including having a drink only, eating a snack, or having a meal (1.92 per participant day), and 1043 evening reports were also recorded (0.94 per participant day). Participants completed 71% of the assessments solicited by random prompting, and 95% of scheduled evening reports. On 615 (32.92%) of randomly-prompted assessments, participants reported they were eating or drinking when prompted. These assessments were treated as eating events, resulting in a total of 2739 eating or drinking events, and 1253 randomly-prompted, non-eating events. Table 3 shows the distribution of eating behaviors reported by self-initiated eating events and captured on random prompt occasions.

< Insert Table 3 about here >

Descriptive Statistics for Snack and Drink Consumption

Drink and snack consumption across the 7 days of EMA data collection for all participants is shown in Table 2. Sweet drinks were consumed on 177 (32.96%) of the drink only occasions and 152 (19.00%) of the snack occasions. The combination of these two types of occasions (n=329) represent the total events coded “1” and all other events were coded “0”

for the sweet drink outcome variable. Sweet drink consumption accounted for 31.1% of all drinks consumed at all drink only, snack, or meal events. Soda was the most common sweet drink at 16.7% of all events (see Table 2), whereas water was the most frequently consumed non-sweet drink at 31.5% of all events (not shown). Sweet snacks were consumed on 289 (36.13%) of the snack events and these occasions were coded “1” for the sweet snack outcome variable. Salty snacks were consumed on 132 (16.50%) of the snack events and these occasions were coded “1 for the salty snack outcome variable. On 29 snacking events (3.63%), both a sweet and salty snack were consumed. This small overlap occurred because participants could indicate consumption of multiple items during an eating event. Participants consumed an unhealthy sweet or salty snack during 49.00% of the snacking events. Sweet drinks, sweet snacks, and salty snacks were consumed during meal events on some occasions, but all of these events were coded “0” according to our *a priori* definition of drink and snack occasions as excluding meals. Meals comprised about half (51.2%) of the drinking and eating events reported. Most meal events included a fruit/vegetable, carbohydrate, and/or a protein (92.3%). None of the meal events was a drink only, and almost none of the meal events included snack items only (2.8%).

Although the PDA devices were disabled during school hours, participants did report that some events occurred at a school location (n=274, 5.4% of total). Events at school occurred mainly during a weekday (n=258, 94.8%) and after 3pm (n=203, 74.6%) when participants may have been attending after school events. The main locations recorded for events at school were on the school grounds (36.0%), in classrooms (23.5%), or at the gym (15.8%). Events recorded as occurring during school hours were primarily between noon and 3pm (n=46, 16.9%), and these few events were recorded retrospectively after school hours.

Univariate Logistic Regressions: Binary EMA Cue Variables

Results for the univariate regressions are presented in Tables 4 and 5 depending upon whether the response type for a cue variable was binary or continuous. Table 4 presents results

for cues with binary (yes/no) response options (e.g., location in the home, yes or no). The three target outcome (dependent) variables are listed in the column headings, and the cues are listed by row in the tables. For each cue in a row, the table lists the proportion of yes responses for that cue, the between person standard deviation of the proportion, and the univariate association between the cue and each of the three target outcomes, sweetened drink, sweet snack, and salty snack consumption. The proportions were calculated by determining the proportion or mean of reports for each day (endorsing a cue once in 4 reports on a given day would result in a proportion of 0.25 for that cue on that day) for each participant using all available days and then calculating the mean proportion per day for the week. Participants who missed an entire day had that day excluded from the calculation (e.g. if a participant only responded 6 out of 7 days the mean would be calculated using a denominator of 6).

< Insert Tables 4 and 5 about here >

Participants frequently reported being at home (64% of the momentary assessment occasions each day), and the cue, being at home, was related to a 25% decreased odds of one target outcome, sweet drink consumption (OR=0.75, p=.031). This implies that if a participant was at home (versus all other response options), then the participant was 25% less likely to report consuming a sweet drink (versus reporting any other non-sweet drink event). The target outcome, sweet snack consumption was associated positively with the cues, being at school, in the family/game room, and on school grounds but occurred most frequently in the family/game room (14% of occasions). This implies that if a participant reported being at school, in the family/game room, or on school grounds (versus all other events that did not report one of these locations), then the participant was more likely to report consuming sweet snacks (versus reporting any other non-sweet snack event). Sweet snack consumption was less likely when outdoors (M=0.06; OR=0.39, p=.007). The target outcome, salty snack consumption was positively associated with the cue, being at school. Participants commonly reported being alone (37%) just before drinking or eating something (or just before a random prompt), but being alone

before eating or drinking was not associated with any of the outcome variables. Certain other social contexts predicted both increased and decreased likelihoods of consuming sweet drinks and salty snacks. The target outcome, consuming sweet drinks was significantly less likely to occur in the presence of the cue, among family members (M=0.42; OR=0.77, p=.047) and was more likely to be consumed in the presence of the cue, among friends (M=0.26; OR=1.38, p=.023). For the target outcome, salty snacks, being in the presence of co-workers as a cue was associated with a greater likelihood of consumption, but reports of being with co-workers when completing assessments were very rare (0.4% of occasions). Only 15 participants (9.49%) reported that they had work after school on one or more days during the week following the baseline assessment.

Using electronic media and watching television were two activities reported fairly often at time of assessments. These activities were associated with an increased likelihood of the target outcome, sweet snack consumption, but not the target outcomes, consumption of sweet drinks or salty snacks. Hanging with friends, an activity reported less often, was associated with a greater likelihood of sweet drink consumption. Reporting the cue, sleeping, was associated with reduced salty snack consumption as a target outcome.

Participants also reported what happened just before consumption occurred, and both visual and social food cues were associated with the outcomes, sweet and salty snack consumption. The cue, seeing snacks, was related to substantially increased odds of consuming sweet drinks (OR=2.19, p<.001), sweet snacks (OR=7.37, p<.001), and salty snacks (OR=5.47, p<.001). The cue, seeing a friend eat (food type not specified), also predicted a greater likelihood of salty snack consumption, and the cue, being offered food by a friend (food type not specified), was related to increased odds of consuming both sweet drinks and salty snacks. Conversely, the cue, being offered food by family members (food type not specified), was associated with decreased odds of sweet drink, sweet snack and salty snack consumption. Participants rarely reported the cue, buying a drink or snack before eating, but as might be

expected, buying a drink or a snack before eating was associated with consumption of sweetened drinks (OR=2.88, p<.001), sweet snacks (OR=1.63, p=.037), and salty snacks (OR=2.21, p=.011).

In contrast to the previous social cue findings noted above, the cue, being alone while eating, was related to sweet snack consumption, and the cue, being with a friend while eating, was related to a greater likelihood of consuming sweet drinks and salty snacks. The cue variable, being with family members while eating, was associated with an increase in the odds of consuming sweet drinks.

Most of the remaining questions with binary response options on the random prompt and eating event reports asked about specific foods and drinks that were consumed. These questions were not included in Table 4 because many of these associations are for overlapping variables such as the regression of the sweet drink outcome variable on soda as a drink option. It is possible, however, that certain other food types may be associated with consumption of the target outcome drinks or snacks acting as cues, substitutes, or complements. For example, the cue, drinking water, was negatively associated with sweetened drink consumption (OR=0.70, p=.042) suggesting that it may be a substitute for drinking soda. Drinking soda may be a substitute for eating sweet snacks (OR=0.55, p=.015) and a cue or a complement for eating salty snacks (OR=1.96, p=.008). Milk may be a substitute for consumption of sweetened drinks (OR=0.31, p=.002) and a cue or complement for eating sweet snacks (or eating sweet snacks may be a cue for drinking a glass of milk: OR=3.99, p<.001). Pure fruit juices appear to substitute for consumption of sweetened drinks (OR=0.27, p=.002) and sweet snacks (OR=0.28, p=.003). Eating sweet snacks and salty snacks may also cue or complement each other. Eating salty snacks was strongly associated with the cues, cookies/pastries/cakes (OR=2.04, p=.023) and candy (OR=3.87, p<.001). Sweet snack consumption was associated with the cues, eating chips (OR=1.72, p=039) and pretzels/crackers (OR=3.58, p=.016).

Univariate Logistic Regressions: Continuous EMA Cue Variables.

Table 5 presents results for cues with continuous response options (e.g., mood, craving, and binging) ranging from 0 to 100 and anchored at 'Not and all' to 'Very much.' The associations between a continuous situational antecedent (a cue) and a binary target outcome (consumption of sweet snacks, salty snacks, or sweet drinks) is reported as an odds ratio that indicate the change in odds of an outcome occurring relative to one standard deviation change in the cue.

Among emotional antecedents, both feeling lonely, a cue with a relatively low mean (M=12.32; OR=1.11, p=.043), and feeling energetic, a cue with a moderate mean rating (M=36.83; OR=1.12, p=.010), were associated with the target outcome, sweet drink consumption. Feeling bored, another emotional cue with a moderate mean rating, was associated with increased sweet snack consumption (M=32.63; OR=1.11, p=.044). None of the aggregated mood scales (i.e., positive mood, negative mood, stress/frustration, tired/bored) tested as cues were associated with the target outcomes.

Food craving cues (0= 'not at all' and 100='very much') also showed an interesting pattern of associations to sweet/salty consumption outcomes. Craving a sweetened drink or a sweetened snack was associated with increased probability of all three target outcomes, consuming a sweet snack, salty snack, or a sweet drink (Table 5). In contrast, the cue, craving a salty snack, was only associated with consuming a salty snack (OR=1.55, p<.001). The cue, craving a meal, which had the highest mean rating among the craving variables (M=42.90), was negatively associated with consuming a sweetened drink (OR=0.87, p<.001) and sweet snack (OR=0.78, p=.004).

Family members rarely criticized participants' food choices, restricted quantity of food, or encouraged them to eat more. Means for these questions ranged from 1.39 to 4.09 on a scale from 0 to 100, and there were no significant associations among these cues and the target outcomes. The last two questions on the random prompt and eating event reports asked about

binge eating on a scale from 0 to 100 and included (a) eating so much that you would be embarrassed (M=7.10) and (b) losing control (M=7.48). These means suggested a low occurrence of binging among these participants, and neither of these cue items was significantly associated with the target outcomes.

Univariate Logistic Regressions: Evening Report Variables (binary and continuous).

Evening reports assessed each day's experience with emotional events, food/drink availability, and activity cues in relation to sweet/salty consumption that day. There was only one evening report per day, but the univariate regression analysis was still two levels, event/day and person (results were not tabled for space considerations). For emotional cues (0= 'not at all' and 100='very much'), participants rated having things go their way fairly high, and this positive emotional cue was associated with a greater likelihood of the target outcome, salty snack consumption (OR=1.17, p=.034). Participants reported having had a good event take place on a given day fairly often (M=0.64), and when the cue was a reported good event related to a friend (M=0.30), the odds of consuming sweet drinks were greater (OR=1.57, p=.020). In contrast, bad events occurred less often, (M =0.37), and these bad event cues were not significantly associated with any of the sweet or salty consumption outcome variables.

The availability of food and drinks in the home was associated with target outcome consumption patterns in a logical way. Generally, if sweet/salty snack foods and sweet drinks were available in the home as potential cues to eat they were more likely to be consumed that day. Conversely, if healthy snacks and drinks were available in the home as cues to eat on a given day, target outcome consumption of unhealthy sweet/salty snacks and sweet drinks was less likely. The presence of soda in the home as a cue to consume sweet drinks, reported by about half of participants on each evening report (M=0.48), was related to a greater likelihood of sweet drink consumption (OR=1.45, p=.030). Meanwhile, the presence of dairy or soy milk in the home as a cue to consume more healthy drinks was reported by about 60% of participants and was associated with decreased odds of sweet drink consumption (OR=0.50, p<.001). The

presence of chips, pretzels and crackers in the home as cues, reported by about half of participants (M=0.54), predicted substantial increase in odds of salty snack consumption (OR=3.12, p<.001). Slightly less intuitive were the consumption patterns when cereal/granola bars (M=0.58) and cookies/pastries/candies (M=0.52) were available in the home as cues to eat. When cereal/granola bars were available in the home on a given day, consumption of sweet drinks was less likely (OR=.61, p=.010). The availability of cookies, pastries, candies in the home, was not associated with sweet snack consumption as one might expect, but did predict significantly decreased odds of salty snack consumption (OR=.61, p=.041).

Finally, being physically active for 60 minutes or more on a given day, which was reported by about 60% of participants, was a cue associated with a greater likelihood of the target outcome, sweet drink consumption (OR=1.40, p=.036), but not sweet or salty snack consumption.

Multiple Logistic Regression

A multiple logistic regression model for each of the three outcome variables was fit to the data in an attempt to determine if the cues were independent predictors of the target outcomes. Cues were included as predictors in the multiple logistic models if they were significant and non-redundant in the univariate regression models. There was a slight reduction in the magnitude of the odds ratios across all cues in the multiple logistic models compared to cues in the univariate logistic models, and some of the cues became non-significant in the multiple logistic models. However, the relative strength of the associations did not change. For example, the multiple logistic regression model for the target outcome, sweet drink consumption, included the following seven predictor cues: bought a drink, saw snacks, hanging with friends, craving a sweet drink, with friends, feeling energetic, and feeling lonely (OR: 2.38, 1.39, 1.29, 1.01, 1.13, 1.00, 1.01, respectively). These effect sizes were smaller in size with 3 of 7 cues becoming non-significant, but the effect sizes were generally in the same rank order as those for the univariate logistic model (OR: 2.88, 2.19, 1.63, 1.43, 1.38, 1.12, and 1.11, respectively). It appears that

there might be some overlap in variance among the cues in the multiple logistic models suggesting that the cues are not completely independent of each other. However, the relative effect sizes (odds ratios) observed in the univariate models are useful indicators of the relative strengths of the associations between the cues and outcomes. The regression results for the sweet snack and salty snack outcomes were similar and are not reported here for space considerations.

Discussion

This is the first study, of which we are aware, to use Ecological Momentary Assessment (EMA) to identify contexts and cues associated with the consumption of sweetened drinks and sweet and salty snacks in a non-clinical sample of adolescents. The objective was to find cue-behavior links that over time might have become stimulus-response (S-R) habits; the identification of these cue-behavior associations has practical implications for the development of dietary behavior interventions. Relatively strong effect sizes (OR>2.0) suggestive of common S-R habits were observed for several social cues and proximal food-related cues. Friend-related cues had relatively strong effect sizes for sweet drinks and salty snacks, with the latter also much more likely to be consumed in the presence of co-workers, who are also likely to be peers. In contrast, sweet snacks were more likely to be eaten when alone. Food-related cues with relatively strong effect sizes included seeing snacks, buying a drink/snack, and consuming food from another sweet drink or snack category (e.g., eating a salty snack was associated with having a sweet drink). The availability of drinks or snacks in the home had a strong effect size for salty snacks, though it was less important for sweet drinks or sweet snacks. These associations suggest the fairly strong influence of social cues and cues specifically associated with food and its availability.

Relatively moderate effect sizes (OR between 1.5 and 2.0) that may also be suggestive S-R habits were observed for two types of cues. Being at school or on school grounds had

moderate effect sizes but only for sweet snacks and salty snacks. Craving a drink or snack also had relatively moderate effect sizes.

A range of mood and other cues were observed with relatively small effect sizes (OR between 1.0 and 1.5), but these are less likely to suggest common S-R habits than those with larger effect sizes. Mood related cues including feeling lonely, energetic, or bored had relatively small effect sizes for sweet drinks and salty snacks and were non-significant for sweet snacks. Although distressed mood has been shown to be an important antecedent in disordered eating populations (see discussion below), it seemed to play a minor role in unhealthy eating in this population. A number of other cues had small effects sizes for sweet drinks (with a family member, physically active 60 minutes during the day), sweet snacks (family/game room, watching TV, using electronic media), and salty snacks (having things go your way during the day).

Multiple logistic regression models fit to the data included predictors that were significant in univariate analyses. The effect sizes (odds ratios) were smaller with some cues losing significance in the multiple logistic models compared to those observed in the univariate models, which suggests that there was some amount of overlap in variance among the cues. However, the rank order for the size of the odds ratios in the multiple logistic models remained similar to those in the univariate models. The odds ratios observed in the univariate models provide useful indications of the relative strengths of the associations between the cues and the target outcomes.

Participants may be unaware of the associations detected by these analyses, and might not be able to accurately endorse these specific cues on traditional surveys that ask participants to recall cues linked to their behaviors retrospectively (Dijksterhuis et al., 2005). EMA permits assessment of the co-occurrence of situations and behaviors in real-world contexts without participants' introspection on cause and effect. An important advantage of the EMA design we used is that it captures base rates (e.g., non-sweet drink and healthy snack events) as well as

the target events (e.g., sweet drink events and unhealthy snacks), which in the current study, allows a reliable estimation of the associations between cues and drink or snack events. This study focused on consumption of sweet drinks and snacks likely to be unhealthy because studies indicate that sweet drinks and snacks play a major role in adolescent obesity, and because adolescents may have more control over snacks than over meals.

These findings derive from adolescents from lower income families, in contrast to other EMA diet studies, which have targeted adolescents with eating disorders. The current sample included a high proportion of Hispanic adolescents, a vulnerable population known to be at risk of obesity (CDC, 2012). The results for the current study are somewhat different from previous studies using EMA, possibly due to differences in study populations and/or in target behaviors. The influence of mood, for example, was limited in the current study but has been important in other populations, especially those with eating disorders or who were trying to achieve or maintain weight loss (Carels et al., 2001; Carels, Douglass, Cacciapaglia, & O'Brien, 2004; Engel et al., 2009; Greeno et al., 2000; Greeno et al., 2000; Hilbert & Tuschen-Caffier, 2007; le Grange et al., 2001; Smyth et al., 2009; Wegner et al., 2002). In the current sample, however, mood did not seem to play a major role in unhealthy snacking. Feeling lonely was associated with having a sweetened drink, but the prevalence of this mood was low compared to feeling energetic, which was also associated with having a sweetened drink. This finding was in contrast to an EMA-based study among obese female adolescents enrolled in a weight management course where negative mood in addition to rumination about daily hassles (stress) was associated with emotional eating (Kubiak, Vogele, Siering, Schiel, & Weber, 2008).

The current study is the first of which we are aware that has used EMA procedures to examine the association of watching TV with eating snacks among a group of adolescents. Prior research has linked snacking with television viewing among youth primarily using traditional surveys (Barr-Anderson, van den Berg, Neumark-Sztainer, & Story, 2008; Boynton-Jarrett et al., 2003; Park, Blanck, Sherry, Brener, & O'Toole, 2012; Skatrud-Mickelson, Adachi-Mejia, &

Sutherland, 2011; Vader, Walters, Harris, & Hoelscher, 2009) or observing behavior in controlled laboratory settings (Blass et al., 2006; Harris, Bargh, & Brownell, 2009). In the current study, watching TV was a relatively common reported activity but was only differentially associated with having a sweet snack, but not with other unhealthy snacks. This may be due to a difference in methodology and/or to the study population. The EMA procedure captures data in real time providing a better measure of the temporal association of TV viewing and snack consumption than traditional surveys and has more ecological validity than laboratory observations, but additional research is needed to clarify reasons for the difference in findings.

The current study is consistent with the results of previous studies on the association between food-related cues and eating behaviors. There is an extensive literature demonstrating increased consumption of food after exposure to food cues such as the sight or aroma of appetizing food (Coelho et al., 2008; Fedoroff et al., 2003; Painter, Wansink, & Hieggelke, 2002; Polivy et al., 2008). Studies that manipulate the availability of food have shown an increased consumption of foods when availability is high (Painter et al., 2002; Thomas, Doshi, Crosby, & Lowe, 2011). This effect was similar in the current study where having chips or soda available in the home was associated with having salty snacks or sweetened drinks. Seeing snacks was also commonly reported in the current study and was strongly associated with consuming a sweetened beverage, a sweet snack, or a salty snack. Buying a drink or snack (after seeing it on the shelf) was also associated with the target behaviors. It was not possible in this study to determine if a participant decided to have a drink or snack before or after seeing it, but the current results are consistent with laboratory studies (Painter et al., 2002). In addition, consumption of sweet snacks was associated with eating salty snack items, exemplifying how eating can be a trigger for further eating. Smelling food, on the other hand, was negatively associated with snack consumption in the current study probably because the smell of food cooking preceded a meal rather than a snack. The current study replicates results from controlled laboratory experiments on food cues in a more ecologically valid setting.

The current study is somewhat consistent with previous findings on the significant influence of peers on dietary behavior (Lally, Bartle, & Wardle, 2011; Wouters, Larsen, Kremers, Dagnelie, & Geenen, 2010). Being with friends and being offered food by friends were associated with consumption of sweetened drinks and salty snacks. In contrast, however, sweet snacks appear to be consumed alone, which is contrary to previous findings. The cited studies did not discriminate between sweet and salty snack types, which may have contributed to the difference with the current study.

Consumption of sweet drinks was positively associated with physical activity during the day in the current study whereas consumption of sweetened soda was negatively associated to physical activity in two national data sets, the 2009 National Youth Risk Behavior Survey and the 2010 National Youth Physical Activity and Nutrition Study (Park et al., 2012; Park, Sherry, Foti, & Blanck, 2012). In both national studies, those who were physically active on 5 or more days per week consumed sweetened soda less often than those who were active on less than 5 days per week. However, those active on 5 or more days consumed more sweetened sport drinks in the latter study (Park et al., 2012). There was no way to determine which type of sweet drink was closely associated in time with physical activity in the current data because the physical activity was assessed in the evening report and beverage consumption was assessed during each event throughout the day. It is unlikely, however, that consumption of sport drinks accounted for the positive association between physical activity and consuming sweetened drinks in the current study. Sport drinks accounted for only 3.2% of the drink events, while participants reported 60 minutes of physical activity on 60% of the evening reports.

Note that the national datasets find that individuals who engage in more physical activity (>60 minutes per day for $\geq$5 days per week) are less likely to drink sweet drinks one or more times per day, whereas our somewhat more detailed analysis shows that sweet drinks were more likely to be consumed on the particular days when subjects also engaged in physical activity, addressing a slightly different within-subjects question. It is possible that sweet drink

consumption may differ if the physical activity occurs during organized sports when access to drinks is limited by adult supervision compared to leisure-type physical activities that are unsupervised. A second possibility is that at least some physically active youth may not be sufficiently hydrated during or immediately after exercise; they may then be prone to drink more impulsively later the same day, that is, to drink whatever good-tasting drink is readily available later on. This could be a momentary effect during the day, reflecting a distinct process only revealed through EMA. It is quite conceivable that momentary effects during the day can be at odds with correlations between general activity level and general levels of sweetened drink consumption revealed in retrospective surveys. However, additional research is needed to empirically evaluate these possible explanations for the surprising finding.

There are several limitations to the current study. First, the correlation between the cue and snacking behaviors reported in the current study does not provide irrefutable evidence of a habitual or causal (S-R) cue-behavior link. Despite strong suggestive evidence, a third variable may be responsible for one or more of the associations. Moreover, the analyses represent contemporaneous or slightly retrospective associations (i.e., participants had already eaten when they made their reports); prospective analyses might provide stronger evidence of the role of cues in eating. Nonetheless, the correlations provide useful information about salient concomitants in the situation preceding the behavior, and these immediate antecedents can be used in a variety of different intervention strategies even if their causal status remains unclear (Stacy et al., 2010; Wood & Neal, 2007), Indeed, the EMA procedure provides an effective combination of real time measures in a naturalistic setting and captures the temporal association of the cue and behavior.

Second, the current analyses were restricted to univariate and multiple regressions that were unadjusted for potential confounds in the data such as time-of-day, day-of-week, gender, BMI, ethnicity, etc. Adjustment for these potential confounds were beyond the scope of this study, which was intended to provide a description of the EMA data set and general results. The

current findings provide important guidance, however, for future studies. Future analysis should examine differences in the links between week days and weekend days and the influence of time of day on the cue associations. Future research should also examine the influence of clusters of cues as well as moderators. Some of the small effects observed in the current data may reflect the fact that participants have idiosyncratic cues that would not emerge in the analysis, or the fact that combinations of cues may be important. An important cluster to examine, for example, may be craving a snack, with a friend, and seeing chips in the kitchen cabinet. Analysis of clusters of cues may also help explain contradictory findings in the current study (e.g., the mixed findings on being with family when having a sweet drink).

A third limitation is that school hours were excluded from the EMA, preventing collection of information about drinks and snack consumption during school hours. Important cues to eating snacks while at school may not be represented in the current results. Finally, the sample of low SES students with a high proportion of Hispanics participants from Southern California may not be representative of low SES students from other areas in the country, but it is very important to study the dietary behaviors of this at-risk population. Future analyses may usefully examine differences between Hispanic and non-Hispanic teens.

Application to Interventions

Research suggests ways of intervening either before or after a habit cue is encountered (Stacy et al., 2010; Wood & Neal, 2007). It may be possible to change the "upstream" circumstances associated with habits to disrupt the cue-habit link (Wood, Tam, & Witt, 2005), and awareness of the situations and cues identified in the current study would be critical to this intervention. For example, unhealthy snack food items may be removed from the home to eliminate the visual cue to eat those items in the kitchen, and to limit their availability. Cues cannot always be removed from a person's environment, but the strategy could certainly be used more frequently where it can be controlled by intervention steps (e.g., in the home, at school). An alternative, "downstream" approach links new actions or other preventive steps in

memory with cues previously linked with an undesirable behavior (Stacy et al., 2010; Wood & Neal, 2007). One of the most promising strategies of this type, termed 'implementation intentions', instructs participants to form if-then action plans in which a specific cue is linked to a planned preventive behavior (Gollwitzer, 1999). An example is the following: "If I come home from school hungry, then I will eat an apple." Some success has been observed for this technique to alter dietary behaviors (Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011). For example, obese and overweight young women lowered consumption of unhealthy snacks and increased consumption of healthy snacks using implementation intentions (Adriaanse et al., 2010). The cognitive mechanisms for these action plans are still being studied (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011; McDaniel & Scullin, 2010), but it seems clear that the cues applied to implementation intentions must be relevant to the behavior (Adriaanse et al., 2010). The current study will help researchers identify these cues. More generally, a range of interventions addressing the links between cues and unhealthy behaviors may be fruitful when addressing any appetitive behavior (Stacy et al., 2010; Wood & Neal, 2007) that exhibits underlying neural processes common in habit formation (Yin & Knowlton, 2006b). Collecting real-world data on the linkage between cues and unhealthy eating is a foundational first step towards potentially effective interventions.

Acknowledgments

Support for this research was provided by the National Institutes of Health (U01 HL097839-01). We especially wish to thank James Pike and Kim Massie for their excellent management of the project and all of the research assistants that help recruit participants and collect data.

Table 1. Descriptive statistics age, ethnicity, SES, and weight.

		Male	Female	Total
Participants	N	68	90	158
	%	43.04	56.96	100.00
Age (years)	M	15.97	15.99	15.98
	SD	1.02	1.04	1.03
Hispanic	N	44	63	107
	%	64.71	70.00	67.72
SES Proxies				
Live with	N	43	47	90
Both Parents	%	65.15	55.95	60.00
Live with	N	14	23	37
Mother Only	%	21.21	27.38	24.67
Mother Completed	N	37	39	76
High School	%	54.41	43.33	48.10
Father Completed	N	34	41	75
High School	%	50.00	45.56	47.47
Weight Indicators				
Height (cm)	M	173.11	160.93	166.17
	SD	5.99	5.35	8.25
Weight (kg)	M	75.06	66.73	70.32
	SD	17.88	16.39	17.49
BMI	M	24.99	25.67	25.38
	SD	5.5	5.65	5.58
BMI Percentile	M	69.93	73.65	72.05
	SD	27.92	24.64	26.08
Normal BMI	N	40	50	90

	%	59	56	57
Overweight	N	10	19	29
	%	15	21	18
Obese	N	18	21	39
	%	26	23	25

Note. Categories based on CDC definitions of normal BMI (5th – 85th percentile), overweight (85th – 95th percentile), and obese (> 95th percentile). No participants met the criteria for the CDC definition of underweight (BMI < 5th percentile). Males in the sample were both significantly taller than females, $t(156) = 13.469$, $p < .001$, and significantly heavier than females, $t(156) = 3.042$, $p = .003$. There was no significant difference in BMI for males and females, $t(156) = .760$, $p = .448$.

Table 2. Consumption of Target Outcome Drinks and Snacks by Food Type.[a]

Target Outcome	Food Types	Drink only (N=537)		Snack with or without a drink[b] (N=800)		Meal with or without a drink[c] (N=1402)	
		N	%	N	%	N	%
Sweetened drinks	soda	75	13.97	69	8.63	311	22.18
	flavored fruit juice	45	8.38	47	5.88	136	9.70
	sport drinks	26	4.84	17	2.13	42	3.00
	coffee/coffee blend	20	3.72	7	0.88	22	1.57
	milk shake	9	1.68	8	1.00	16	1.14
	energy drinks	11	2.05	7	0.88	8	0.57
	Total[d]	177	32.96	152	19.00	523	37.30
Sweet snacks	Cookies/pastries/cakes			147	18.38	62	4.42
	Candy			81	10.13	30	2.14
	Cereal/granola bar			76	9.50	23	1.64
	Total[d]			289	36.13	108	7.70
Salty snacks	Chips			103	12.88	59	4.21
	Pretzels/crackers			19	2.38	7	0.50
	French fries			14	1.75	17	1.21
	Total[d]			132	16.50	78	5.56

Sweet or salty snack	Total[d]	392	49.00	160	11.41

[a] Food types for contrasting categories of healthy drinks, snacks, and meals are not presented for space considerations.
[b] Each snack event/occasion may or may not include a drink.
[c] Each meal event/occasion may or may not include a drink.
[d] Multiple items could be consumed and reported for in a single eating event, so total events may be less than the sum of individual items.

Table 3. Number of eating events entered by type of EMA report.

	Random Prompt Entries[a]		Eating Event Entries		All Eating Assessments	
	N	N/day[b]	N	N/day[b]	N	N/day[b]
Just a drink	167	0.15	370	0.33	537	0.48
Snack with or without a drink	188	0.17	612	0.55	800	0.72
Meal with or without a drink	260	0.24	1142	1.03	1402	1.27
Total	615	0.56	2124	1.92	2739	2.48

[a] A total of 2637 random prompts were issued and participants responded to 1868 (70.84%) of those prompts (mean per day = 1.69). Participants reported drinking and/or eating something on 615 (32.92%) of the 1868 prompts to which they responded (one additional participant abandoned a random event report after indicating she/he was eating something on the first question).
[b] Based upon the actual number of responses and actual days completed by participants.

Table 4. Random event/eating event binary items frequencies and bivariate odds ratios.

Question	Option	Mean per Day[a]	SD per Day[b]	Odds Ratio[c]		
				Sweet Drinks	Sweet Snacks	Salty Snacks
Where were you just before eating/drinking?	Home	0.643	0.186	0.753*	1.069	0.712
	Other person's home	0.086	0.108	1.142	0.762	1.110
	Stores/entertainment	0.037	0.062	1.625	0.851	0.549
	School	0.084	0.101	0.879	1.706*	1.948*
	Vehicle	0.049	0.069	1.533	1.242	1.201
	Outdoors	0.065	0.094	1.066	0.387**	1.215
	None of the above	0.037	0.063	1.466	1.098	1.271
[If at home…] Where at home?	Bedroom	0.311	0.203	0.766	0.906	0.744
	Kitchen/dining room	0.151	0.127	0.789	1.030	0.817
	Family/game room	0.143	0.156	1.129	1.471*	1.232
	Yard	0.013	0.031	1.532	0.930	0.264
	Bathroom	0.011	0.025	1.129	0.082	0.593
	Other	0.014	0.038	0.628	0.855	0.884
	Not applicable	0.357	0.186	1.327*	0.935	1.404
[If in a store…] What kind of store?	Grocery store	0.005	0.018	1.493	0.927	1.528
	Mall/food court	0.010	0.030	0.753	1.086	0.245
	Restaurant/fast food	0.014	0.034	2.162	0.524	0.198
	Movie theater	0.001	0.004	6.898	0.000	0.274
	Gaming store	0.001	0.011	0.227	0.000	1.000
	Other	0.007	0.021	1.290	1.417	0.976
	Not applicable	0.963	0.062	0.615	1.176	1.820
[If at school…] Where at school?	Classroom	0.016	0.035	0.755	1.960	1.556
	Cafeteria	0.006	0.024	0.692	0.878	3.244

Question	Option	Mean per Day[a]	SD per Day[b]	Odds Ratio[c]		
				Sweet Drinks	Sweet Snacks	Salty Snacks
	Gym	0.015	0.051	0.698	1.838	1.251
	Library	0.002	0.008	0.564	0.177	1.000
	School grounds	0.032	0.057	1.319	2.100*	1.715
	Parking lot	0.003	0.016	0.140	0.006	0.161
	Other	0.010	0.032	0.679	1.097	3.532
	Not applicable	0.916	0.101	1.138	0.586*	0.513*
Were you alone?		0.367	0.199	1.090	0.944	0.725
[If not alone…] Who were you with? (Check all that apply)	Family	0.415	0.208	0.770*	1.058	0.829
	Friends	0.263	0.178	1.377*	0.864	1.459
	Teams/Clubs/Groups	0.036	0.071	1.566	0.798	1.882
	Classmates/peers	0.043	0.073	0.787	1.362	0.811
	Co-workers	0.004	0.017	0.083	1.123	6.727**
	Others	0.025	0.069	0.620	0.971	1.252
What were you doing? (Check all that apply)	Using electronic media	0.418	0.223	1.145	1.324*	1.048
	Coming from school	0.070	0.077	1.359	1.545	1.130
	Working	0.023	0.053	0.906	0.713	0.728
	Hanging with friends	0.139	0.132	1.634**	0.968	1.202
	Sleeping	0.088	0.087	0.692	0.616	0.420*
	Exercising	0.078	0.111	1.387	0.761	0.754
	Studying/reading	0.085	0.102	0.736	0.845	0.782
	Other activity	0.296	0.208	0.983	0.997	1.607*
[if electronic media…] What electronic media? (Check all that apply)	Watching TV	0.217	0.178	1.289	1.461*	0.911
	Computer/video games	0.103	0.122	0.764	1.112	0.948

Question	Option	Mean per Day[a]	SD per Day[b]	Odds Ratio[c]		
				Sweet Drinks	Sweet Snacks	Salty Snacks
	Working on a computer	0.029	0.055	0.753	0.896	1.038
	IM/email on computer	0.027	0.064	1.086	1.164	1.775
	Texting	0.164	0.203	1.203	1.162	1.336
	Listening to music	0.101	0.138	0.998	0.869	0.642
	Other	0.024	0.103	0.357	0.429	0.470
What happened just before you drank/ate? (Check all that apply)	Smelled food	0.156	0.154	0.845	0.354***	1.078
	Saw snacks	0.143	0.147	2.191***	7.371***	5.470***
	Saw friend eating	0.039	0.068	1.076	0.670	2.248*
	Friend offered food	0.054	0.075	1.728*	0.921	2.205*
	Family offered food	0.153	0.132	0.546**	0.525**	0.426**
	Bought drink/snack	0.060	0.072	2.878***	1.627*	2.211*
	None of the above	0.565	0.217	0.708**	0.417***	0.300***
Did you eat by yourself?		0.437	0.223	1.120	2.377***	1.421
[If not alone..] Who were you with? (Check all that apply)	Friend	0.160	0.133	2.204***	1.344	2.204***
	Family member	0.246	0.174	1.445**	0.788	0.894
	Classmate/peer	0.019	0.041	0.958	0.936	1.347
	Others	0.028	0.060	2.503**	0.491	1.267

[a] Mean proportion of 'yes' responses per day: Response options were 'Yes' or 'No' (Yes=1, No=0).
[b] Standard deviation of the between person means.
[c] Odds ratios are the increase in odds for an outcome (sweet drinks, sweet snacks, or salty snacks) for the designation response option relative to all other options for a single question.
[d] Sweetened drinks;
[e] Sweet snacks;
[f] Salty snacks.
*p<.05
**p<.01
***p<.001

Table 5. Random event/eating events for continuous items means and odds ratios.

Question	Option	Mean per Day[a]	SD per Day[b]	Odds Ratio[c]		
				Sweet Drinks	Sweet Snacks	Salty Snacks
Were you feeling… (range 0 – 100)	Tired	45.509	21.437	0.985	0.965	0.941
	Stressed	22.583	18.681	1.005	1.048	1.003
	Sad	15.812	16.765	1.076	1.046	0.961
	Relaxed	54.710	19.990	1.014	0.953	0.972
	Lonely	12.324	16.247	1.106*	1.002	0.997
	Left-out	8.410	12.528	1.052	1.043	0.993
	Happy	57.436	18.489	1.035	0.979	1.049
	Frustrated	22.335	18.517	0.975	1.000	0.901
	Energetic	36.829	19.517	1.120**	1.026	0.994
	Embarrassed	7.244	9.919	1.074	1.018	1.003
	Cheerful	42.312	21.241	1.038	1.094	1.132
	Bored	32.629	22.822	0.958	1.110*	1.029
	Angry	14.842	13.841	1.008	0.972	1.021
Aggregate Positive Mood (not a question)		39.700	13.648	1.104	1.017	1.051
Aggregate Mood – Stress/frustration (not a question)		51.390	52.561	1.096	1.018	0.992
Aggregate Mood – Tired/bored (not a question)		44.929	35.305	0.987	1.030	0.940
Aggregate Negative Mood (not a question)		78.161	37.847	0.961	1.034	0.963
Were you craving a …. (range 0 – 100)	Sweet snack	28.477	19.292	1.113**	1.742***	1.164**
	Salty snack	19.915	17.364	1.060	1.013	1.549***

Question	Option	Mean per Day[a]	SD per Day[b]	Odds Ratio[c]		
				Sweet Drinks	Sweet Snacks	Salty Snacks
	Sweetened drink	38.477	23.090	1.428***	1.139**	1.166*
	Non-sweetened drink	37.263	24.341	0.959	1.038	1.023
	Fruits or vegetables	34.572	21.137	1.026	1.000	1.027
	Meal	42.898	19.389	0.867***	0.781***	0.919
Were you criticized by family member about what you were eating?	(range 0 – 100)	1.390	2.740	1.005	0.999	0.947
Did a family member limit what you could eat?	(range 0 – 100)	2.171	6.800	1.011	1.050	0.971
Did a family member encourage you to eat more?	(range 0 – 100)	4.086	7.496	0.991	0.980	0.996
Binge Eating 1	Eating so much, would be embarrassed if seen	7.101	12.505	1.056	0.911	0.952
Binge Eating 2	Feeling a loss of control	7.480	10.291	1.081	0.919	1.056

[a] Means for response options on a range of 0 – 100 and anchored ‘Not at all’ and ‘Very much.’
[b] Standard deviation of the between person means.
[c] Odds ratios are the increase in odds for an outcome (sweet drinks, sweet snacks, or salty snacks) for one standard deviation change in the response option.
*p<.05
**p<.01
***p<.001

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