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ORIGINAL ARTICLE

Psychological eating factors, affect, and ecological momentary assessed diet quality

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Abstract

Purpose Eating behaviors are a contributor to obesity, yet more research is needed examining time varying and time-invariant factors associated with food consumption. Psychological eating factors (e.g., restraint, disinhibition, and susceptibility to hunger) and affect have been associated with obesity and diet. However, less is known about how psychological eating factors and affect are associated with food consumption assessed in daily life. The purpose of this study was to examine associations among psychological eating factors, affect, and food consumption using ecological momentary assessment (EMA) in a non-clinical sample of college students.

Method Young adults ($N = 30$; $M_{age} = 21$) completed traditional self-report measures of psychological eating factors and usual dietary intake and EMA measures of food consumption and affect.

Results Momentary negative affect was associated with greater sugary beverage consumption, and sugary food consumption in the past 2.5 h was associated with report of higher current negative affect. Susceptibility to hunger, disinhibited and emotional eating, and baseline unhealthy eating were positively related to sugary food consumption. Lower susceptibility to hunger was associated with more sugary beverage intake. Finally, increased aggregate EMA negative affect and positive affect were related to increased fruit consumption, and lower susceptibility to hunger and baseline unhealthy eating were associated with vegetable consumption.

Conclusions Results provide support for the role of time varying and invariant factors in predicting eating behaviors in daily life; both may be important to consider in obesity prevention and intervention. Particularly, ecological momentary interventions targeting affective states in individuals' daily lives may be useful for changing food intake.

Level of evidence Level IV, multiple time series.

Keywords Eating behaviors · Affect · Ecological momentary assessment · Restraint · Disinhibition · Diet quality

Introduction

Obesity and related health problems, including diabetes and cardiovascular disease, are major public health concerns, and are associated with psychosocial challenges and increased healthcare costs [1–3]. Diet quality is a leading contributing factor to obesity. Research shows that most adults consume too much sugar [4] and too few fruits and vegetables [5], and intake of sugary foods and beverages is associated with cardiovascular disease mortality [4] and obesity [6, 7]. Further, sugary food and beverage consumption is associated with lower satiety, increased subjective hunger, and low nutritional quality, which increases energy intake and weight gain [6, 8, 9]. In contrast, fruits and vegetables are a rich source of nutrients [10] and are related to lower risk of chronic disease [11–14]. Specifically, college students are an at-risk group for weight gain and unhealthy eating, which makes this an important sub-group in which to study factors related to food consumption [15, 16].

Research has demonstrated that person-level psychological eating factors, including dietary restraint (cognitive attempts to monitor and restrict eating), disinhibited eating (tendency to eat in response to non-hunger-related stimuli such as emotions or sight of food), and hunger (susceptibility to subjective feelings of hunger), are positively associated with disordered eating behaviors and weight [17]. Yet, less is

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known about how these psychological eating characteristics are associated with normative eating behaviors. Restraint has not been found to be associated with caloric intake assessed in the naturalistic environment [18]; however, restraint is related to increased consumption of vegetables and less consumption of sugary and fried foods [19]. Also, individuals higher in disinhibited eating reported greater consumption of unhealthier foods and had poorer diet habits [19, 20]. Further, susceptibility to hunger has been associated with increased overall caloric intake [21]. Therefore, some evidence suggests that psychological eating factors are related to dietary quality, but this data are limited by use of primarily retrospective diet recall.

While such person-level psychological factors undoubtedly play a role in eating, momentary factors, such as affect, are increasingly gaining interest by researchers and have been shown to be related to eating behaviors [22–26]. Positive affect (PA) has been associated with choosing healthier foods [22, 23] and negative affect (NA) has been associated with an increased consumption of foods high in fat, sugar, and carbohydrates [24–26]. Theories suggest that when individuals experience PA, they may have better ability to make healthier decisions [27]. Further, individuals may choose healthy foods to maintain the PA state [28]. With regard to NA and unhealthy eating, individuals may eat unhealthy foods to cope with negative emotions, such as anger or sadness [29]. Historically, research on affect and food consumption has utilized cross-sectional, daily diary, and 24-h recall methods. End-of-day diaries and 24-h recall are better than cross-sectional methods, but this methodology has significant limitations. For example, they are subject to recall bias typical of many cross sectional and self-report studies [30].

One method to overcome these limitations is ecological momentary assessment (EMA). EMA involves repeated measurements of participants' experiences and behaviors within their natural environment [31]. EMA aids in minimizing recall bias by assessing participants in real time, thereby reducing measurement error. EMA also aids in examining contextual associations between affective, cognitive, and behavioral factors occurring over a short time period by allowing disaggregation of within-subjects and between-subjects effects [31, 32]. Within-subjects effects characterize how momentary variation in a construct compared to one's average is related to the outcome, and between-subjects effects characterize how an individual's average level of a construct is related to the outcome. Additionally, for researchers examining food consumption, EMA provides a more powerful tool for capturing daily food intake compared to more common approaches (i.e., Food Frequency Questionnaires and 24-h recall). EMA allows for assessment of variation in food consumption rather than merely providing an assessment of usual diet quality and not displaying variability in food consumption/specific types of foods eaten (e.g., "meat" versus "beef" or "chicken") [33]. Most EMA eating research has examined disordered eating behaviors (e.g., binge eating and loss of control eating). For example, studies have found that increased NA and lower PA precipitate binge eating [34, 35]. Thus, more research is needed utilizing EMA to examine normative food consumption in the naturalistic environment.

EMA research on momentary associations between affect and eating has produced mixed results. Studies have illuminated bi-directional associations between within-subjects PA and fruit/vegetable intake where higher PA predicts subsequent fruit/vegetable intake and fruit/vegetable intake predicts subsequent higher PA [36, 37]. Several studies have found no within-subjects associations between affect and unhealthy eating in either direction in mother–child dyads; although, these studies found that between-subjects NA was related to more unhealthy food intake and less fruit/vegetable intake [36, 37]. A separate EMA study found that within-subjects PA was related to increased intake of sweets, but there were no relations with NA [38]. Further, an EMA study of healthy college students found no between- or within-subjects associations between affect and healthy eating [39].

Elucidation of within-subjects relationships among affect and eating can lead to the development of ecological momentary interventions, which are interventions that occur in individuals' natural environment and provide intervention material when it is most needed [40]. Further, determining between-subjects, or individual difference factors, related to eating may inform novel-targeted treatments for individuals [41, 42]. Thus, the purpose of this study was to examine associations among affect, self-reported psychological eating factors, and eating using EMA. This study served to try to reconcile mixed findings by investigating bi-directional associations between affect and eating and using a novel qualitative approach to capture eating in EMA; participants provided a detailed list of foods eaten in a text box with no word limit if they consumed food in EMA. First, we hypothesized that higher PA and lower NA would be associated with better diet quality. Second, we hypothesized that disinhibited eating and hunger would be associated with poorer diet quality and dietary restraint would be associated with better dietary quality. Third, we hypothesized that higher body mass index (BMI) and poorer baseline diet quality would be associated with poorer EMA diet quality.

Method

Participants and procedure

Participants were 30 undergraduate students enrolled in psychology courses at a U.S. university (50% female; $M_{age} = 21.00$, SD = 3.99; range = 18–33). The sample was

White (43.3%), followed by African-American (23.3%), Asian-American (23.3%), Hispanic/Latino (6.7%), and other (3.3%). Participants' BMI ranged from 18.24 to 29.69 ($M = 24.19$, SD = 2.68). The sample was predominately normal weight (64.3%; BMI: 18.5–24.9), followed by overweight (32.1%; BMI: 25.0–29.9), and underweight (3.6%; BMI: < 18.5).

Students were screened through an online survey system and interested, eligible participants were invited to attend an information session until the sample of 30 was obtained. During the online survey screening, participants were made aware that not all eligible individuals would be asked to participate and that participants would be chosen at random. At the session, individuals completed an informed consent form, baseline questionnaire, and a practice session where they responded to each of the items in the EMA questionnaire. Given that we wanted to focus on normative diet quality and not pathological eating episodes, such as binge eating (as there is a large body of research on this topic [43]), participants were excluded for a variety of reasons (see Table 1). For example, certain disorders or symptomatology (e.g., schizophrenia, depression) could influence how individuals respond to EMA questions, thus impacting affect. Out of the 230 individuals who were interested in participating, 71 (30.9%) were eligible (exclusion criteria were not mutually exclusive). All procedures were approved by the Institutional Review Board of Virginia Commonwealth University.

Using a fixed sampling scheme, each participant completed EMA assessments for 6 days (Thursday–Tuesday) to capture weekdays and weekends [44, 45]. Administering approximately five to seven EMA recordings daily is fairly standard practice [34, 35, 46], so we administered six daily measurements every 2.5 h. Assessments began at 9:30 am and ended at 10:00 pm. See Fig. 1 for a sample timeline of EMA measures and analyses in the current study. Utilizing an automated text messaging service (ProTexting), participants received a text message with a website link, which prompted them to complete the EMA questionnaire (designed specifically for mobile use). A response was considered missing if a participant did not respond within 30 min of the prompt. They were compensated with course credit and up to $50.00. Participants who completed 90% or more of the assessments received $50.00. Payments were prorated for individuals who completed less than 90% of the assessments. For example, an individual who completed 80% of the assessments received $40.00 (0.8 × $50.00 = $40.00).

Baseline measures

Demographics

Participants reported demographic information including gender, race/ethnicity, age, weight, and height.

Table 1 Reasons and numbers of participants excluded

Exclusion criterion[a]	*n*	%
Phone type[b]	58	25.2
No Texting	2	0.9
No Internet	26	11.3
Depression[c]	63	27.4
Schizophrenia[d]	1	0.4
Bipolar[d]	1	0.4
Eating restrictions[d]	12	5.2
Physical activity restrictions[d]	10	4.3
Fear of fat[e]	19	8.3
Binging[e]	62	27.0
Vomiting[e]	12	5.2
Laxatives[e]	7	3.0
Diuretics[e]	5	2.2
Diet pills[e]	16	7.0
Fast[e]	15	6.5
Excessive exercise[e]	17	7.4

$N = 230$. [a]Criteria overlap among participants. [b]Needed an iPhone or Android phone. [c]Assessed with Center for Epidemiologic Studies Depression scale (CES-D) [32]; 10 or higher was indicative of depression [33]. [d]Self-reported illness/disability. [e]Items used in the Mid-Atlantic Twin Registry [34, 35] were used to assess eating disorder symptoms

Three-Factor Eating Questionnaire (TFEQ) [47]

The 51-item TFEQ is a widely used measure of dietary restraint, susceptibility to hunger, and disinhibition. The Restraint subscale has 21 items, and a sample item is: "I deliberately take small helpings as a means of controlling my weight"; the Hunger subscale has 14 items, and a sample item is: "How often do you feel hungry?"; and the Disinhibition subscale has 16 items, and a sample item is: "When I feel blue, I often overeat." Evidence of internal consistency, test–retest reliability, and construct validity has been provided previously [47]. Cronbach's coefficient alphas for the current study were: dietary restraint ($\alpha = 0.88$), susceptibility to hunger ($\alpha = 0.72$), and disinhibition ($\alpha = 0.64$). Six items were eliminated to improve internal consistency of the disinhibition scale (improved from $\alpha = 0.36$ to $\alpha = 0.64$). Items that were removed involved weight cycling, splurging on food, binge eating, and leaving food on one's plate. These items may not be as central to the disinhibition construct or may not have had much variability in a sample of 30 individuals.

Eating and appraisal due to emotions and Stress Questionnaire (EADES) [48]

A 12-item subscale of the EADES was used to measure emotional eating on a scale from 1 (strongly disagree) to 5 (strongly agree). A sample item is: "I use food to cope with

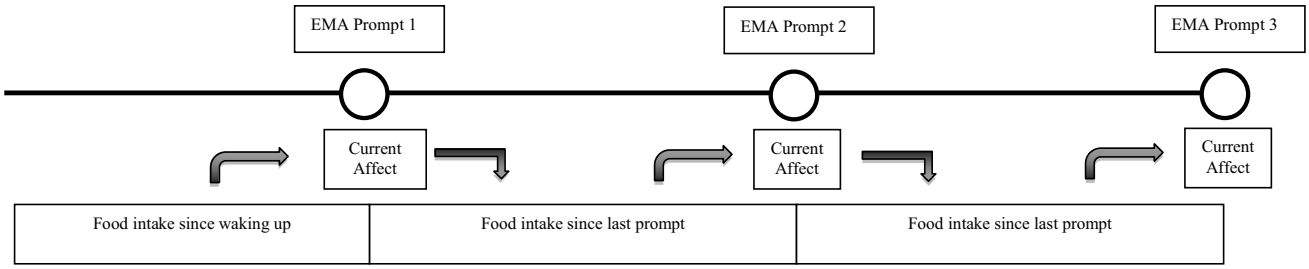

Fig. 1 Sample timeline of ecological momentary assessment measures and analyses in the current study

my emotions" (reverse scored). Psychometric properties for the EADES have been provided in a university sample [48]. Cronbach's coefficient alpha for the current study was $\alpha = 0.90$.

Food Frequency Questionnaire [49]

Participants reported on usual healthy and unhealthy food intake using a 12-item questionnaire. This measure is similar to other validated Food Frequency Questionnaires and has been used in past research [50]. Participants reported how often they eat certain foods (e.g., fruits, cakes/cookies) on a scale ranging from 1 (never) to 5 (several times a day).

EMA measures

Affect

Affect was measured using six items from the Positive and Negative Affect Scale (PANAS) [51]. Three words were used to assess PA: enthusiastic, excited, and inspired ($\alpha = 0.87$). Three words were also used to assess NA: upset, scared, and nervous ($\alpha = 0.74$). Items were chosen due to their high factor loadings in the short version of the PANAS. Participants rated their current affect on a scale from 1 (very slightly or not at all) to 5 (extremely).

Food consumption

Foods eaten within the last 2.5 h were assessed using two questions. Participants indicated whether or not they had eaten. If participants reported they had eaten, they were prompted to provide a detailed list of foods eaten in a text box with no word limit. At the study's in-person information session, participants were instructed to be as detailed as possible regarding what they ate and the amount. The principal investigator walked the participants through various examples. For example, participants were told to not simply answer "pizza," but to respond with "2 slices of pepperoni pizza." They were instructed to provide amounts of food, but were not required to give exact serving sizes. Past research has employed this type of open-ended response [52]. Measuring food intake in EMA is relatively new, and there is no standard method.

Statistical analyses

After consulting with a registered dietitian regarding food group categorization, two independent raters (doctoral students) coded all eating events, including snacking, meals, and beverages. Each eating event was coded as including sugary beverages (sodas, lattes), high-sugar foods (cookies, cake), fruits (apples, bananas), and/or vegetables (salads, veggie pizza). Fruits in desserts were not coded as fruit. High-sugar episodes included foods with added sugars and/or approximately 10 g of sugar, which would represent 20–40% of a person's daily allotted sugar intake, as indicated by specifications from the World Health Organization [53]. Coding disagreements were resolved through discussion among the two independent raters and a health psychologist.

Generalized estimating equations (GEEs) were calculated to analyze the data using SPSS 22.0. GEEs account for non-independence of observations in the data (observations nested within persons) and accommodate data with missing time points [54]. The autoregressive (AR1) serial autocorrelation correction was used to account for dependences within the nested data [54]. Momentary assessments (level 1) were nested within participants (level 2), and day was included as a covariate in within-person models. Level one variables (i.e., PA and NA), which were captured in the EMA protocol, had repeated measures for each participant. Level two variables modeled between-person effects or individual differences.

First, GEEs with a binary logistic function were calculated with affect as a predictor of dietary quality at the next EMA assessment point (i.e., $t+1$) within the same day. NA and PA were examined as predictors in separate models, and each food outcome was examined in a separate model. NA and PA were person-mean centered to allow for examination of within- and between-person effects. Specifically, this allowed us to examine the association between both

momentary levels of PA and NA as well as average level of PA and NA over the course of the EMA period in relation to dietary quality.

Second, GEEs with a gamma function were calculated with past 2.5 h dietary quality as a predictor of current affect within the same day. Each food item was examined as a predictor in separate models, and each of the NA and PA was used as separate dependent variables. Each food intake item was person-mean centered to allow for examination of within- and between-person effects.

Third, in separate GEEs, we examined associations between between-subjects BMI, psychological eating factors (i.e., dietary restraint, disinhibition, and susceptibility to hunger), emotional eating, and baseline unhealthy and healthy eating in relation to momentary diet quality (i.e., sugary beverages, sugary foods, fruits, and vegetables). This allowed us to examine associations between individual differences in BMI, psychological eating factors, emotional eating, and baseline healthy and unhealthy eating and EMA dietary quality.

Results

There were 924 usable EMA assessments out of a potential total of 1080 indicating a high response rate (85.6%). The mean number of signals responded to was 30.63 (SD = 5.51; range = 13–36). On average, participants responded to 5.11 prompts per day (SD = 0.92). Twenty-eight assessments were excluded due to timing issues, such as the participant answering the last assessment of the night the following morning (e.g., 1:00 am); the remaining 128 assessments were unusable due to missingness. There were a total of 383 eating events (i.e., EMA prompts in which any eating was reported, including multiple eating events within one EMA prompt). Cohen's κ indicated good inter-rater reliability (0.92, 0.79, 0.93, and 0.85 for fruit, vegetables, sugary foods, and sugary beverages, respectively). There were 49 fruit events, 50 vegetable events, 133 sugary food events, and 66 sugary beverage events. No differences were found between eating on weekdays versus weekends.

Affect and dietary quality

Affect predicting dietary quality

Table 2 displays results of models of affect predicting diet quality. Within-subjects NA predicted likelihood of consumption of sugary beverages at the next prompt. Between-subjects NA was significantly related to increased likelihood of sugary food consumption demonstrating that individuals who reported more NA over the course of the EMA period were more likely to consume sugary foods. Both increased between-subjects NA and PA were related to higher likelihood of fruit consumption demonstrating that individuals who reported more NA and PA over the course of the EMA period were more likely to consume fruits. Neither between- nor within-subjects affect was associated with vegetable consumption.

Diet quality predicting affect

Table 3 displays results of models of diet quality predicting affect. There was a significant association between within-subjects sugary food consumption and higher NA. Thus, at moments when participants consumed sugary foods or beverages in the previous 2.5 h, they reported higher current NA. Between-subjects fruit consumption was related to higher PA. Neither between- nor within-subjects vegetable or sugary beverage consumption was associated with affect.

Table 2 General estimating equations of affect predicting dietary quality

	Fruit			Vegetable			Sugary food			Sugary beverage		
	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*
Negative affect												
Within-subjects	0.08	0.09	0.41	0.21	0.13	0.10	−0.03	0.08	0.67	**0.27**	**0.12**	**0.03**
Between-subjects	**0.38**	**0.09**	**< 0.001**	−0.16	0.08	0.06	**0.25**	**0.09**	**0.007**	−0.10	0.28	0.72
Positive affect												
Within-subjects	−0.06	0.09	0.49	0.01	0.1	0.89	−0.03	0.080	0.70	0.13	0.09	0.16
Between-subjects	**0.21**	**0.10**	**0.03**	−0.07	0.09	0.43	0.09	0.09	0.32	−0.14	0.11	0.23

Within-subjects and between-subjects negative affects were examined in one model, and within-subjects and between-subjects positive affects were examined in a second model

Bold text represents $p < 0.05$

SE standard error, *Level 1* $N = 383$, *Level 2* $N = 30$

Individual difference variables and dietary quality

Associations between individual difference variables and dietary quality are displayed in Table 4. Lower susceptibility to hunger and lower general (baseline) unhealthy diet were associated with increased likelihood of consuming vegetables. Increased disinhibition, more susceptibility to hunger, higher emotional eating, and general (baseline) unhealthy diet were associated with greater likelihood of sugary food consumption. Higher BMI and lower susceptibility to hunger were associated with greater likelihood of sugary beverage intake. General (baseline) healthy diet and restraint were unrelated to diet quality.

Discussion

The primary aim of this study was to examine associations among self-reported psychological eating factors, affect, and food consumption. This study used EMA to measure moment-to-moment food consumption, which minimized recall bias and allowed for investigation of within-person fluctuations in consumption opposed to general intake. Also, past EMA eating research has focused on disordered eating and affect [29, 30], thus our study extends the literature by examining bi-directional associations between specific food choices and affect in the naturalistic environment. We found some support for our hypotheses in that: (1) higher PA and lower NA were associated with aspects of healthier food consumption, (2) increased

Table 3 General estimating equations of dietary quality predicting affect

	Negative affect			Positive affect		
	Estimate	SE	*p*	Estimate	SE	*p*
Fruits						
Within-subjects	0.03	0.04	0.57	0.03	0.05	0.58
Between-subjects	0.62	0.63	0.33	**1.37**	**0.49**	**0.005**
Vegetables						
Within-subjects	0.01	0.05	0.82	−0.03	0.06	0.64
Between-subjects	−0.19	0.46	0.67	−0.93	0.76	0.22
Sugary foods						
Within-subjects	**0.06**	**0.03**	**0.02**	−0.05	0.04	0.20
Between-subjects	0.56	0.33	0.09	0.48	0.43	0.26
Sugary beverages						
Within-subjects	0.09	0.05	0.09	0.06	0.06	0.33
Between-subjects	−0.03	0.25	0.90	−0.27	0.26	0.29

Within-subjects and between-subjects diet quality were examined in four separate models

Bold text represents $p < 0.05$

SE standard error, *Level 1* $N = 383$, *Level 2* $N = 30$

Table 4 General estimating equations of individual difference variables and dietary quality

	Fruit			Vegetable			Sugary food			Sugary beverage		
	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*	Estimate	SE	*p*
Body mass index	−0.05	0.08	0.56	0.04	0.05	0.45	−0.06	0.05	0.20	**0.38**	**0.08**	**<0.001**
TFEQ disinhibition	−0.16	0.09	0.07	−0.004	0.08	0.97	**0.26**	**0.08**	**0.002**	0.06	0.15	0.71
TFEQ hunger	−0.01	0.07	0.89	**−0.11**	**0.05**	**0.03**	**0.14**	**0.04**	**0.001**	**−0.20**	**0.07**	**0.003**
TFEQ restraint	0.05	0.04	0.21	0.04	0.03	0.22	−0.03	0.03	0.37	−0.01	0.07	0.89
EADES emotional eating	−0.001	0.023	0.96	−0.01	0.02	0.55	**−0.05**	**0.01**	**<0.001**	−0.04	0.04	0.35
FFQ unhealthy diet	0.30	0.36	0.42	**−0.53**	**0.20**	**0.01**	**0.52**	**0.22**	**0.02**	−0.62	0.41	0.13
FFQ healthy diet	0.35	0.28	0.21	0.28	0.20	0.17	−0.34	0.24	0.16	−0.26	0.44	0.55

Each variable was tested in a separate model

Bold text represents $p < 0.05$

SE standard error, *TFEQ* Three-Factor Eating Questionnaire, *EADES* Eating and Appraisal Due to Emotions and Stress Questionnaire, *FFQ* Food Frequency Questionnaire, *Level 1* $N = 383$, *Level 2* $N = 30$

disinhibited eating and hunger were associated with aspects of unhealthier food consumption, and (3) higher BMI and poorer baseline diet quality were associated with aspects of poorer food consumption.

Sugary food consumption was associated with psychological eating variables, including susceptibility to hunger, disinhibited and emotional eating, as well as between- and within-subjects NA. These findings are consistent with prior research using other assessments of food intake [20, 21, 52], but our study provides evidence for associations using ecologically valid data. Also, results showed that momentary NA predicted sugary beverage consumption. Thus, when college students experience more NA, they may be more likely to choose sugary beverages. Further, consumption of sugary foods in the past 2.5 h was associated with reporting lower NA. Consistently, a recent meta-analysis showed that carbohydrate consumption was related to more fatigue and less alertness compared to a control [55]. Efforts to reduce sugar consumption should address how individuals' negative affective states can influence their food choices.

Higher BMI and lower susceptibility to hunger were associated with increased sugary beverage intake. The relation between higher BMI and sugary beverage consumption is unsurprising given that sugar-sweetened beverage intake is associated with obesity [6, 7]. Additionally, people who are less susceptible to hunger, may choose to drink sugar-sweetened beverages, which are less filling yet still satisfying, rather than eating food or meals. For example, a college student who generally feels less hungry may drink a sugar-sweetened coffee in the morning opposed to food or may consume a sugary drink as a snack instead of food.

Findings regarding between-person PA and fruit intake are consistent with previous research [22, 23]. Given that fruit provides energy and healthy nutrition, individuals might feel good about choosing to eat fruit. Fruit was also related to more NA over the course of the EMA period. This finding was unexpected; it may be that intensity of affect (i.e., high versus low) is more associated with fruit intake compared to valence of affect (i.e., positive versus negative). Also, lower susceptibility to hunger was associated with vegetable consumption. People who eat more vegetables may be less susceptible to hunger due to prolonged satiety given high amounts of fiber in vegetables [56]. Further, people highly susceptible to hunger cues may reach for energy dense, sugary snacks instead of vegetables.

EMA addressed some methodological limitations of previous research. Participants were assessed multiple times a day and responses were timestamped. These assessments were roughly 2.5 h apart which minimized the potential for retrospective recall biases, which overcomes limitations of previous research using retrospective surveys and 24-h recalls [33]. In addition, the open-ended dietary assessment approach allowed for more information to be obtained from participants regarding their food intake. Participants were also allowed to use their own cell phones, which may have enhanced compliance due to user-friendliness and minimal intrusion [30]. Finally, given that all participants were assessed during the same days of the week, all participants had weekend and weekday measurements rather than a variation in days of the week across participants.

Limitations include having a relatively small sample size of college students particularly at the between-subjects level recruited from psychology courses from one university. While examining obesogenic eating behaviors among college students without obesity is important given they are an at-risk group for obesity [57], generalizability of findings to other groups may be limited. Despite the benefits of EMA methodology, assessments were based upon self-report. Further, this study employed signal-contingent recordings only, which may have resulted in an underreporting of eating events. Also, given that our EMA protocol utilized defined intervals, and not random time points, participants could predict the timing of the subsequent prompt. Participants could have changed their behavior accordingly (e.g., eaten a healthy snack prior to receiving a text). Additionally, we did not take into account portion size except for sugar amount.

There were multiple waves of participants that were assessed at different times. Responses may have differed among participants due to varying school workloads (e.g., full-time versus part-time), summer vacation, change in weather, holidays, and availability of various foods. However, considerations were made to keep some consistency regarding assessment times. For example, no participant was assessed during finals week. The study was limited to iPhone and Android smartphone users with both Internet and text messaging services. These technology restrictions excluded some interested participants, particularly those of lower socioeconomic status, but roughly 70% of the participants were eligible based on these exclusion criteria. Another limitation includes the modification of the Disinhibition subscale of the TFEQ, which could have changed the meaning of the score. Also, given the non-experimental nature of the study, causality cannot be inferred.

Future research should assess a more generalizable sample, such as a wider variety of college students and their non-college peers. In addition, more research is needed to examine differences in the association of affect and diet quality by time-invariant (e.g., weight status) and time-variant (e.g., location) factors. Future research should also examine how fluctuations in psychological eating factors at the momentary level are associated with dietary quality. Utilizing event-contingent recordings, i.e., having participants record each time they eat, would also be beneficial in reducing recall/memory errors. Studies would also benefit from incorporating more objective ratings of food intake, such as taking photos of food consumed. Further, future studies might also examine

calories, portion/serving size of foods, and snacking versus meals, which have been utilized in some prior research [58].

Despite the limitations, this study provides further evidence of the association between psychological eating factors and affect in relation to food intake assessed in the natural environment. Clinicians in college/university settings may want to assess psychological eating factors and affect when screening for unhealthy behaviors. Further, results could help inform healthy eating campaigns, particularly for college students. For example, campaigns might highlight specific techniques to deal with emotional, disinhibited eating including focusing on positive cognitive–emotional coping skills (e.g., identifying potential stressors related to unhealthful eating), and appetite awareness strategies focused on hunger and satiety. Finally, ecological momentary interventions targeting affective states in individuals' daily lives may be useful for changing food intake [40]. For example, interventions should specifically aim to reduce NA, which may in turn reduce consumption of sugary foods and beverages.

Author contributions Authors AJ and EB designed the study and wrote the protocol. Authors AJ and TM conducted the literature searches and provided summaries of previous research studies. Authors AJ and TM conducted the statistical analyses. Authors AJ and TM wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of Virginia Commonwealth University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Centers for disease control and prevention. CDC speakers bureau—topics at a glance. http://www.cdc.gov/speakers/subtopic/speechTopics.html. Accessed 7 August 2012
2. Kelly SJ, Daniel M, Dal Grande E, Taylor A (2011) Mental ill-health across the continuum of body mass index. BMC Public Health 11(765):1–11
3. Finkelstein E, Trogdon J, Cohen J, Dietz W (2009) Annual medical spending attributable to obesity: payer-and service-specific estimates. Datawatch 28:822–831
4. Yang Q, Zhang Z, Gregg EW, Flanders WD, Merritt R, Hu FB (2014) Added sugar intake and cardiovascular diseases mortality among US adults. JAMA Intern Med 174(4):516–524
5. Sanchez A, Norman GJ, Sallis JF, Calfas KJ, Rock C, Patrick K (2008) Patterns and correlates of multiple risk behaviors in overweight women. Prev Med 46:196–202
6. Malik VS, Schulze MB, Hu FB (2006) Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr 84:274–288
7. Te Morenga L, Mallard S, Mann J (2013) Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ 346:e7492
8. Pan A, Hu FB (2011) Effects of carbohydrates on satiety: differences between liquid and solid food. Curr Opin Clin Nutr Metab Care 14:385–390
9. Poti JM, Slining MM, Popkin BM (2014) Where are kids getting their empty calories? Stores, schools, and fast-food restaurants each played an important role in empty calorie intake among US children during 2009–2010. J Acad Nutr Diet 114(6):908–917
10. Slavin JL, Lloyd B (2012) Health benefits of fruits and vegetables. Adv Nutr 3:506–516
11. Dauchet L, Amouyel P, Hercberg S, Dallongeville J (2006) Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. J Nutr 136(10):2588–2593
12. He FJ, Nowson CA, MacGregor GA (2006) Fruit and vegetable consumption and stroke: meta-analysis of cohort studies. Lancet 367(9507):320–326
13. Abdel-Megeid FY, Abdelkarem HM, El-Fetouh AM (2011) Unhealthy nutritional habits in university students are a risk factor for cardiovascular diseases. Saudi Med J 32(6):621–627
14. Ford ES, Mokdad AH (2001) Fruit and vegetable consumption and diabetes mellitus incidence among US adults. Prev Med 32(1):33–39
15. Deshpande S, Basil MD, Basil DZ (2009) Factors influencing healthy eating habits among college students: an application of the health belief model. Health Mark Q 26(2):145–164
16. Laska MN et al (2012) Interventions for weight gain prevention during the transition to young adulthood: a review of the literature. J Adolesc Health 50(4):324–333
17. Bohrer BK, Forbush KT, Hunt TK (2015) Are common measures of dietary restraint and disinhibited eating reliable and valid in obese persons? Appetite 87:344–351
18. Goldstein SP, Katterman SN, Lowe MR (2013) Relationship of dieting and restrained eating to self-reported caloric intake in female college freshmen. Eat Behav 14(2):237–240
19. De Lauzon B, Romon M, Deschamps V, Lafay L, Borys JM, Karlsson J, Charles MA (2004) The Three-Factor Eating Questionnaire-R18 is able to distinguish among different eating patterns in a general population. J Nutr 134(9):2372–2380
20. Ganasegeran K, Al-Dubai SAR, Qureshi AM, Al-abed AAA, Rizal AM, Aljunid SM (2012) Social and psychological factors affecting eating habits among university students in a Malaysian medical school: a cross-sectional study. BMC Nutr 11:11–48
21. French SA, Mitchell NR, Finlayson G, Blundell JE, Jeffery RW (2014) Questionnaire and laboratory measures of eating behavior. Associations with energy intake and BMI in a community sample of working adults. Appetite 72:50–58
22. Fedorikhin A, Patrick VM (2010) Positive mood and resistance to temptation: the interfering influence of elevated arousal. J Consum Res 37(4):698–711
23. Griffin KW, Friend R, Eitel P, Lobel M (1993) Effects of environmental demands, stress, and mood on health practices. J Behav Med 16(6):643–661
24. Jones F, O'Connor DB, Conner M, McMillan B, Ferguson E (2007) Impact of daily mood, work hours, and iso-strain

variables on self-reported health behaviors. J Appl Psychol 92(6):1731–1740
25. Christensen L (1993) Effects of eating behavior on mood: a review of the literature. Int J Eat Disord 14(2):171–183
26. Tice DM, Bratslavsky E, Baumeister RF (2001) Emotional distress regulation takes precedence over impulse control: if you feel bad, do it! J Pers Soc Psychol 80(1):53–67
27. Isen AM (2001) An influence of positive affect on decision making in complex situations: theoretical issues with practical implications. J Consum Psychol 11(2):75–85
28. Wansink B, Cheney MM, Chan N (2003) Exploring comfort food preferences across age and gender. Physiol Behav 79(4–5):739–747
29. Polivy J, Herman CP (1993) Etiology of binge eating: psychological mechanisms. In: Fairburn CG, Wilson GT (eds) Binge eating: Nature, assessment, and treatment, pp 173–205. Guilford Press, New York, NY, US
30. Smyth JM, Stone AA (2003) Ecological momentary assessment research in behavioral medicine. J Happiness Stud 4:35–52
31. Shiffman S, Stone AA, Hufford MR (2008) Ecological momentary assessment. Annu Rev Clin Psychol 4:1–32
32. Cervone D (2005) Personality architecture: within-person structure and processes. Annu Rev Psychol 56:423–452
33. Kristal AR, Peters U, Potter JD (2005) Is it time to abandon the food frequency questionnaire? Cancer Epidemiol Biomark Prev 14(12):2826–2828
34. Engel SG, Wonderlich SA, Crosby RD, Mitchell JE, Crow S, Peterson CB, Gordon KH (2013) The role of affect in the maintenance of anorexia nervosa: evidence from a naturalistic assessment of momentary behaviors and emotion. J Abnorm Pychol 122:709
35. Smyth JM, Wonderlich SA, Heron KE, Sliwinski MJ, Crosby RD, Mitchell JE, Engel SG (2007) Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. J Consult Clin Psychol 75(4):629
36. Mason TB, O'Connor SG, Schembre SM, Huh J, Chu D, Dunton GF (2019) Momentary affect, stress coping, and food intake in mother–child dyads. Health Psychol 38(3):238–247
37. Liao Y, Schembre SM, O'Connor SG, Belcher BR, Maher JP, Dzubur E, Dunton GF (2018) An electronic ecological momentary assessment study to examine the consumption of high-fat/high-sugar foods, fruits/vegetables, and affective states among women. J Nutr Edu Behav 50(6):626–631
38. Ashurst J, Van Woerden I, Dunton G, Todd M, Ohri-Vachaspati P, Swan P, Bruening M (2018) The association among emotions and food choices in first-year college students using mobile-ecological momentary assessments. BMC Public Health 18(1):573
39. Schultchen D, Reichenberger J, Mittl T, Weh TR, Smyth JM, Blechert J, Pollatos O (2019) Bidirectional relationship of stress and affect with physical activity and healthy eating. Br J Health Psychol 24(2):315–333
40. Heron KE, Smyth JM (2010) Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. Br J Health Psychol 15(1):1–39
41. Bryan AD, Jakicic JM, Hunter CM, Evans ME, Yanovski SZ, Epstein LH (2017) Behavioral and psychological phenotyping of physical activity and sedentary behavior: implications for weight management. Obesity 25:1653–1659
42. Kelly AS, Marcus MD, Yanovski JA, Yanovski SZ, Osganian SK (2018) Working toward precision medicine approaches to treat severe obesity in adolescents: report of an NIH workshop. Int J Obes 42:1834–1844
43. Engel SG, Crosby RD, Thomas G, Bond D, Lavender JM, Mason T, Wonderlich SA (2016) Ecological momentary assessment in eating disorder and obesity research: a review of the recent literature. Curr Psychiatry Rep 18(4):37
44. Thompson FE, Larkin FA, Brown MB (1986) Weekend-weekday differences in reported dietary intake: the nationwide food consumption survey, 1977–78. Nutr Res 6(6):647–662
45. Haines PS, Hama MY, Guilkey DK, Popkin BM (2003) Weekend eating in the United States is linked with greater energy, fat, and alcohol intake. Obesity 11(8):945–949
46. Dunton GF, Huh J, Leventhal AM, Riggs N, Hedeker D, Spruijt-Metz D, Pentz MA (2014) Momentary assessment of affect, physical feeling states, and physical activity in children. Health Psychol 33:255
47. Stunkard AJ, Messick S (1985) The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. J Psychosom Res 29:71–83
48. Ozier AD, Kendrick OW, Knol LL, Leeper JD, Perko M, Burnham J (2007) The eating and appraisal due to emotions and stress (EADES) questionnaire: development and validation. J Am Diet Assoc 107:619–628
49. Mikolajczyk RT, Ansari WE, Maxwell AE (2009) Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. Nutr J. 8:31
50. Osler M, Heitmann BL (1996) The validity of a short food frequency questionnaire and its ability to measure changes in food intake: a longitudinal study. Int J Epidemiol 25:1023–1029
51. Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: the PANAS scales. J Pers Soc Psychol 54(6):1063–1070
52. O'Connor DB, Jones F, Conner M, McMillan B, Ferguson E (2008) Effects of daily hassles and eating style on eating behavior. Health Psychol 27(Suppl. 1):S20–S31
53. World Health Organization (2015) WHO calls on countries to reduce sugars intake among adults and children. http://www.who.int/mediacentre/news/releases/2015/sugar-guideline/en/. Published March 4, 2015
54. Schwartz JE, Stone AA (1998) Strategies for analyzing ecological momentary assessment data. Health Psychol 17:6–16
55. Mantantzis K, Schlaghecken F, Sünram-Lea SI, Maylor EA (2019) Sugar rush or sugar crash? A meta-analysis of carbohydrate effects on mood. Neurosci Biobehav Rev 101:45–67. https://doi.org/10.1016/j.neubiorev.2019.03.016
56. Pasman WJ, Saris WHM, Wauters MAJ, Westerterp-Plantenga MS (1997) Effect of one week of fibre supplementation on hunger and satiety ratings and energy intake. Appetite 29(1):77–87
57. Morrell JS, Lofgren IE, Burke JD, Reilly RA (2012) Metabolic syndrome, obesity, and related risk factors among college men and women. J ACH 60(1):82–89
58. Patel KA, Schlundt DG (2001) Impact of moods and social context on eating behavior. Appetite 36:111–118