Motivation and Hedonic Hunger as Predictors of Self-Reported Food Intake in Adolescents:

Disentangling Between-Person and Within-Person Processes

By

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Abstract

Background: Dietary behavior contributes substantially to health across the lifespan. Understanding interactions between stable characteristics and fluctuating drive states underlying youth's food choices may inform methods for promoting more healthful food intake. The present study examined dietary motivation and hedonic hunger as interacting predictors of adolescents' consumption of *sweet*, *starchy*, *fatty*, and *fast foods*.

Methods: Intensive longitudinal data were collected from 50 adolescent participants (ages 13-18) over a 20-day study period. Participants completed a measure of dietary motivation at baseline and reported on hedonic hunger and consumption of palatable foods via a smartphone application at the end of each study day.

Results: Results indicated that 66.7% of the variability in hedonic hunger was between-person and 33.3% was within-person. Between-person hedonic hunger was positively associated with consumption of *fatty* foods ($\beta = .28$, $p < .05$) and within-person hedonic hunger was positively associated with consumption of *starchy* foods ($\beta = .38$, $p < .0001$). A significant cross-level interaction indicated that as hedonic hunger increased, the slope relating controlled motivation to starchy food consumption become more strongly positive. Autonomous motivation was negatively associated with consumption of *fast foods* ($\beta = -.14$, $p < .05$). Additionally, the interaction term of within-person hedonic hunger and autonomous motivation indicated that as hedonic hunger increased, the slope relating autonomous motivation to *fast food* consumption became more strongly negative.

Conclusions: Findings indicate that hedonic hunger has the potential to fluctuate over time, but conceptualization of the variable as both trait and state may be most appropriate given the current findings. Results confirmed that unique relationships exist between trait motivation and fluctuating hedonic hunger, and that the interactions of these variables may hold value in understanding and addressing unhealthful dietary choices. In particular, adolescents with high controlled motivation for diet may be vulnerable to the influence of hedonic hunger and especially prone to eating higher quantities of *starchy* foods. Adolescents with high autonomous motivation for diet may be less vulnerable to the experience of hedonic hunger and less likely to consume *fast food*.

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Motivation and Hedonic Hunger as Predictors of Self-Reported Food Intake in Adolescents: Disentangling Between-Person and Within-Person Processes

Importance of Dietary Choices

Current dietary guidelines highlight the need for regulating food consumption by avoiding intake that exceeds caloric need and moderating calories from added sugars, trans fats, and saturated fats (U.S. Department of Agriculture, 2015). These recent recommendations highlight the importance of all food and beverage choices and emphasize healthy eating across the lifespan (USDA, 2015). Incorporating these guidelines into daily eating habits is fundamental to promoting health and decreasing risk for chronic illness.

Childhood and adolescence are especially important periods during which to examine and address dietary behavior, as these are key developmental stages when food consumption habits are formed that can result in later health consequences (Birch & Fischer, 1998; Osei-Assibey et al., 2012; Reilly & Kelly, 2011). Adolescence in particular is an important period to study given the expectation of increased independence, including more freedom to make one's own food choices (Stok, De Ridder, Adriaanse, & De Wit; 2010). Indeed, the result of this increased independence is often marked by poor dietary choices. In fact, as much as 40% of 14-18 year olds' daily food consumption consists of low nutrient foods high in solid fat and added sugars (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010; Reedy & Krebs-Smith, 2010). This widespread poor diet is a main contributor to the continuing national epidemic of overweight and obesity (Ogden, Carroll, Kit, & Flegal, 2014), high blood pressure, elevated cholesterol levels, and insulin resistance, all of which lead to morbidity and mortality in adulthood (Gunther et al., 2015; Reilly et al., 2003; Reilly & Kelly, 2011). Understanding the processes that influence adolescents' food consumption will inform efforts to improve youth's physical health and weight status, intending to also result in better health in adulthood. The current project will examine motivation to consume a healthy diet, and appetitive drive for highly palatable food, as interacting predictors of food intake.

Dietary Motivation and Food Intake

Dietary motivation appears to be a key influencer of food consumption. Self-determination theory (SDT) provides a useful framework for understanding the motives that may drive food consumption (Deci & Ryan, 1985a). SDT posits that people are motivated by the three innate needs of autonomy, competence, and relatedness (Deci & Ryan, 1985a, 2000; Levesque et al., 2007; Ryan & Deci, 2000). Within SDT, autonomous motivation is thought to guide behavior that is important or valuable to oneself, independent from judgement from others. Moreover, this type of motivation is characterized by taking responsibility and pride in the choices one makes. In contrast, controlled motivation is characterized by a desire to please others, fit in with social norms, gain respect, or avoid guilt or shame. Deci and Ryan found that change driven by controlled motivation, or external influences, led to generally negative outcomes in achieving long-term goals and decreased the likelihood of lasting habit change, while behavior driven by autonomous motivation, or intrinsic factors, had the opposite effect (2000, 2008).

These motivation concepts have been studied in the context of various health behaviors, including diet (Levesque et al., 2007). A recent study in adults found autonomous motivation and goal setting to predict more healthful food choices, such as eating more fruits and vegetables, and controlled motivation to predict choices for less healthful foods, such as eating more sweet and savory foods (Hartmann, Dohle, & Siegrist, 2015). It is relevant to note that although some interventions have successfully increased autonomous motivation for particular health behaviors, such changes seem to require focused and intentional effort (Williams, Cox, Kouides, & Deci, 1999). In accordance with this notion, the SDT framework maintains that motivation represents enduring, individual differences in the regulation of behavior, with tendencies toward either autonomy or control, and is not expected to fluctuate within a given person (Deci & Ryan, 1985b). Dietary motivation, in particular, has been found to be resistant to change even in light of a specific intervention (Rutten et al., 2014), and thus would not be expected to change spontaneously in an individual. To date, there is a paucity of literature focusing on dietary motivation in children and adolescents. The limited work that does exist, supports similar conclusions to those available from the adult literature. Specifically, one recent study found adolescents' intrinsic motivation for healthy eating to be linked to more fruit and vegetable consumption (Niermann, Kremers, Renner, & Woll, 2015). Overall, more research is needed regarding motivation for health behaviors in youth. In particular, given that motivation is likely to be resistant to change (Rutten et al., 2014), it is important to study motivational processes in the context of psychological states that do fluctuate and may be targets for intervention.

Hedonic Hunger and Food Intake

One such variable that may have a fluctuating state component is hedonic hunger. Hedonic hunger refers to an appetitive drive to consume highly palatable foods for pleasure, which is in contrast to the physiological need for calories that characterizes homeostatic hunger (Lowe & Butryn, 2007). Hedonic hunger is thought to have emerged recently in human history, as modern society has transitioned into a food environment where palatable food is widely available to adults and children, both in terms of convenience and economic cost (Borradaile et al., 2009; Painter, Wansink, & Hieggelke, 2002). Sometimes referred to as the obesogenic environment (Gorin & Crane, 2008), these surroundings provide no restriction in the quantity of food available, and thus, contribute to increased food intake and subsequent weight gain. Though hedonic hunger refers to appetite for pleasurable foods, rather than the consumption of these foods, it is reasonable to study hedonic hunger as a predictor of food consumption and to consider its potential effect on individual weight and rates of obesity. Findings of parallel fluctuations in weight and hedonic hunger following bariatric surgery provide support for these proposed relationships (Cushing et al., 2014; Shultes, Ernst, Wilms, Thurnheer, & Hallschmid, 2010). Specifically, adolescents who underwent gastric bypass surgery for extreme obesity experienced reductions in both BMI and hedonic hunger 18 months post-operation, as well as increases in both BMI and hedonic hunger at 24 months post-operation (Cushing et al., 2014). Findings from this work indicates that hedonic hunger should continue to be studied in adolescents and that the variable is indeed associated with weight changes, as well as the fluctuations in food consumption that drive them.

Measures of hedonic hunger are designed to assess behavioral responses that indicate appetite, using items such as, *I get more pleasure from food than I do from almost anything else*, and *Just before I taste a favorite food I feel intense anticipation* (Lowe et al., 2009). Researchers differentiate hedonic hunger from homeostatic hunger by highlighting that food palatability is integral to the definition of hedonic hunger, and that hedonic hunger would be most effectively studied in the absence of a caloric energy deficit (Lowe et al., 2009). However, other studies consider hedonic hunger to be an informative construct regardless of energy status and have found hedonic hunger not to be affected by varying levels of homeostatic hunger (Witt & Lowe, 2014; Witt, Raggio, Butryn, & Lowe, 2014). Nevertheless, it is most appropriate to measure hedonic hunger and to identify food preoccupation in well-nourished populations where food supply is plentiful and available. In such an environment where overexposure to high-calorie food seems to be constant, it can be assumed that variability in overconsumption of palatable foods is most likely due to individual psychobiological processes (Lowe & Butryn, 2007).

Results of research examining the relationship between hedonic hunger and excess consumption of palatable foods have been mixed; however, hedonic appetite has generally been considered a risk factor for overeating (Blundell & Finlayson, 2004). In the adult literature, some studies show hedonic hunger to be positively associated with overeating (Manasse et al., 2015) and predictive of loss of control eating (Lowe et al., 2016), while other studies show no relationship of hedonic hunger with excess food consumption or weight status (Lowe & Butryn, 2007). For example, a recent study found that hedonic hunger did not predict short term effects of overconsumption of highly palatable foods, but did predict higher food consumption overall (Ely, Howard, & Lowe, 2015). Other relevant research found that hedonic hunger was associated with overeating, but only when adult participants exhibited low inhibitory control (Appelhans et al., 2011). Relevant literature focused on youth includes the notion that children ages 11 to 15 may have particular reward sensitivity for high sugar foods, indicating a possible vulnerability for hedonic hunger (Spear, 2010). Other recent work has found support for measuring hedonic hunger in youth samples (Laurent, 2015) and found hedonic appetite to be present in children as young as 9 years old (Laurent & Sibold, 2015). Moreover, one study found that children high in impulsivity may tend to eat more energy-dense foods both in the presence and absence of hunger, which may be relevant to understanding hedonic appetite (Nederkoorn, Dassen, Franken, Resch, & Houben, 2015). Still, there is currently limited research regarding hedonic hunger and food consumption in samples of children and adolescents. Further investigation is needed to explore the relationships among hedonic appetite, intake of palatable foods, and implications for weight status in youth.

Measuring Hedonic Hunger

Though the concepts and theories regarding dietary motivation discussed above have been researched for decades, less is known in terms of how they relate to hedonic hunger and pediatric weight-related health. Additionally, there remains some debate about whether hedonic hunger is best measured as a between-person (trait) or within-person (state) variable. The existing literature indicates that hedonic eating may be best measured contemporaneously with its occurrence, perhaps through ecological momentary assessment (EMA; Lowe & Butryn, 2007). One EMA study that examined obesogenic eating behavior and hedonic hunger found that the interaction between BMI and availability of palatable foods predicted overeating, in that individuals with higher BMI were more susceptible than those with lower BMI to overeating when palatable foods were present in the immediate environment (Thomas, Doshi, Crosby, & Lowe, 2011). However, findings from another study suggest that hedonic hunger can be considered a stable construct that should not vary significantly with daily variations in hunger or exposure to food in the immediate environment (Witt, Raggio, Butryn, & Lowe, 2014). Studying hedonic hunger through EMA methods allowed for an empirical answer to whether hedonic hunger is best measured between or within persons, and subsequently, how to model the effect of hedonic hunger on food intake.

Present Study

The overlapping background literature regarding food consumption, hedonic hunger, and dietary motivation make it apparent that quality and quantity of dietary choices, and understanding the processes that drive them, are key to adolescent health. While acknowledging that motivation influences eating habits, there seem to be other non-goal-oriented drive states, such as hedonic hunger, that also influence eating behavior. Additionally, though the application of self-determination theory to dietary choices holds value in helping us understand what motivates individuals to make particular dietary choices, we must also consider how hunger and drive states interact with goal-oriented motivation constructs to determine behavior. Examining and understanding how stable traits, such as motivation, relate to fluctuating appetitive drives, such as hedonic hunger, provides clarity regarding the multiple influences on health-related behaviors, which are key to health and well-being.

The present study aimed to determine whether hedonic hunger functions as a between-person or within-person construct and to examine the relationships among dietary motivation, hedonic hunger, and food intake. We addressed these aims through testing the following hypotheses: (1) Hedonic hunger was expected to vary over time and be modeled best by including both between-person and within-person variability; (2) Hedonic hunger (both between-person and within-person) was expected to be positively related to consumption of palatable foods (i.e. *sweet, starchy, fatty,* and *fast foods)*; (3) Autonomous motivation was expected to be negatively related to consumption of palatable foods; (4) Controlled motivation was expected to be positively related to consumption of palatable foods; (5) Within-person hedonic hunger was expected to moderate the respective relationships between dietary motivation and palatable food consumption, such that high hedonic hunger and high controlled dietary motivation were expected to predict the most consumption of these foods, and that low hedonic hunger and high autonomous motivation were expected to predict the least consumption of these foods (See Figure 1). Evaluating the associations among these variables allowed us to further understand implications for youth's diet-related health and possible targets for prevention and intervention. Additionally, the study provided insight relevant to promoting healthful mindsets for children and adolescents' eating behaviors.

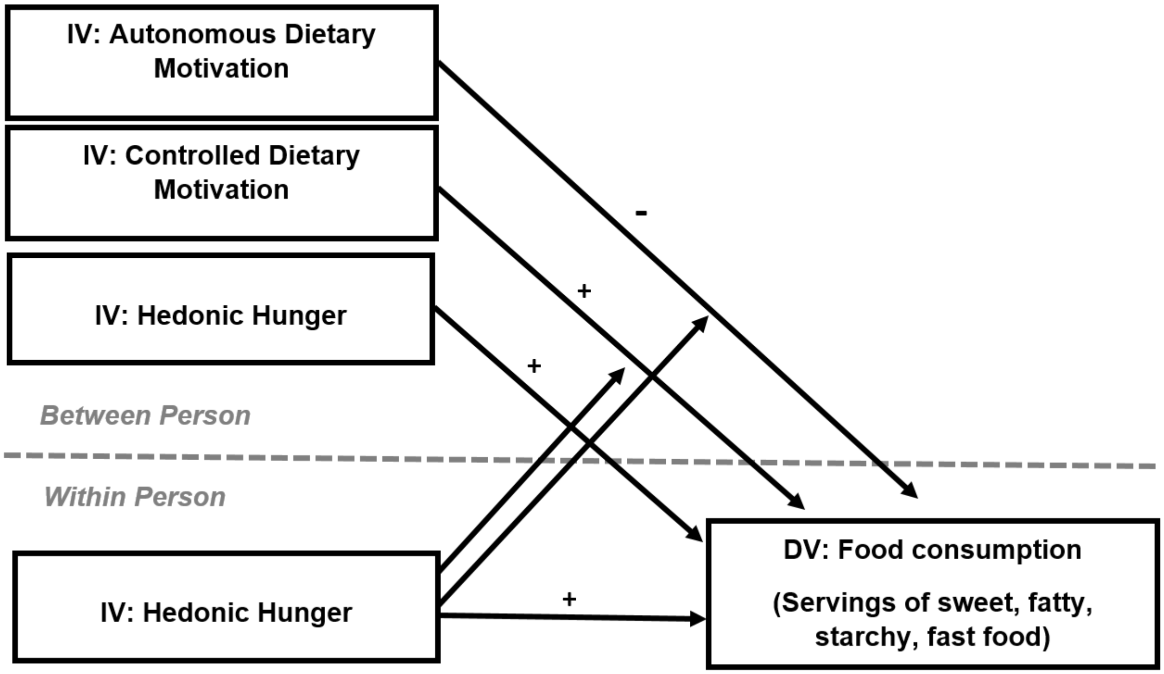


Figure 1. Conceptual model reflecting hypotheses that within-person hedonic hunger will moderate respective relationships between autonomous motivation and food consumption, and controlled dietary motivation and food consumption.

Methods

Participants

The participant sample consisted of 50 adolescents, ages 13-18 (M = 14.70, SD = 1.49). Recruitment occurred in a Midwestern city. Tactics included posting flyers in local businesses and areas of public recreation, reaching out to school principals for assistance in providing students and parents with information about the study, and distributing information at community events (e.g. farmers' markets; sporting events). Informational flyers communicated that adolescents ages 13 through 18 were invited to participate in a 20-day study that used technology to learn about physical activity, diet, sleep, affect, and related constructs, and that participants had the opportunity to earn up to $40. Eligibility criteria included the ability to read at grade level in English, absence of significant visual impairments, and absence of any physical conditions that would limit physical activity. The 50 adolescents enrolled represented approximately 62.5% of total parent-adolescent dyads who contacted the research team with interest in the study.

Procedure

All protocols and materials were approved by the Institutional Review Board prior to commencing recruitment or study procedures. Interested participants who learned about the study through community recruitment contacted the research team by telephone. A member of the research staff provided additional information about the study procedures, completed a brief screening to determine participant eligibility, and communicated with parents to ensure that they were willing to allow their adolescents to participate. The adolescent-parent dyad were scheduled to come in for an initial visit in the research lab located at the local university.

Initial Study Visit. At the initial study visit, the research staff reviewed the informed consent form with parents and the assent form with adolescents, addressed any questions from parents and adolescents, and obtained signed copies of both forms. Each participant then completed a demographic form and an activity calendar, and their height and weight were recorded. The research staff directed adolescent participants to complete questionnaires at a computer. After completing baseline measures, participants completed training on use of the smartphone app that administered survey questions over the 20-day course of the study. Adolescents and parents discussed daily schedules with the research staff to determine four times throughout each day (e.g., 8 a.m., 12 p.m., 3:30 p.m., and 8 p.m.) during which the adolescent could complete a brief 3-5 minute survey. The research staff programmed the agreed upon survey times into the smartphone app and showed the participants how the survey app would function.

Research staff encouraged adolescents to complete the surveys as they were notified, based on the agreed upon schedule, emphasizing that participants would receive maximum payment for the phone survey portion of the study ($25) if they complete all four surveys on at least 17 of the 20 days they are in the study (i.e. 85% of surveys). As part of a larger protocol not yielding data for the current study, participants were also trained to wear a heart rate monitor and informed that they could earn $.75 each day that they wore it for 12 hours, to earn up to $15. The $25 available for compliance with the phone surveys combined with the $15 available for compliance with the heart rate monitor totaled the $40 compensation that participants could earn through this study. Participants were also informed that they would be allowed to turn the phone off, if needed, so that an alarm would not sound (e.g. at a movie theater). Participants were provided the smartphone, locked with a passcode so that only the survey app would be accessible. The initial visit lasted approximately one hour in duration and an exit visit was scheduled approximately 20 days later. Overall, previous work has suggested that adolescents exhibit a high rate of compliance with a similar study protocol (Brannon, Cushing, Crick, & Mitchell, 2016).

Smartphone app. The PETE smartphone app was developed as an EMA tool to measure time-varying (within-person) constructs. The app can be programmed to administer surveys at specific times throughout the day. When it is time to complete a survey, an alarm sounds to notify the participant, and continues to sound until the first question has been answered. If a participant happens to have the phone off during a survey notification, the alarm would then sound once the phone was turned back on, and the participant could complete the survey at that time. The data were stored on the smartphone and downloaded from the phone onto a computer at the exit visit.

Final Study Visit. At the exit visit, participants returned equipment and completed questionnaires as part of the larger study protocol. Research staff downloaded participants' answers to the phone surveys and determined how many questionnaires were completed over the study period. Compliance with wearing the heart rate monitor was also determined, and participants were paid a portion, or the full amount of the $40. Participant payment was made through the Greenphire ClinCard system.

Constructs

Height and weight. Each participant's height and weight were measured at the initial study visit. Participants were asked to remove excess attire (e.g. footwear, hats, sweatshirts, and jackets) in order to obtain accurate measurements. Research staff measured height on a stadiometer to the nearest 0.1 cm and weight on a digital scale to the nearest 0.1 kg. Measurements were taken three consecutive times and averaged. Body mass index (BMI) percentile was calculated based on age and sex, as indicated by the Centers for Disease Control (CDC, 2007).

Demographics. Participants completed a demographic questionnaire, with assistance from parents as needed. The questionnaire included items about gender, date of birth, age, race and ethnicity, and indicators of family socioeconomic status (See Table 1).

Table 1

Demographic Characteristics of Adolescent Participants and their Families

Demographic Variable	n = 50	%
Gender		
Male	20	40
Female	30	60
Race/Ethnicity		
Caucasian	35	70
African American	2	4
Hispanic/Latino	7	14
Asian	1	2
Other/Multiracial	4	8
Approximate Family Income		
< $10,000	1	2
$10,000-$20,000	3	6
$21,000-$30,000	3	6
$31,000-$40,000	2	4
$41,000-$50,000	2	4
$51,000-$60,000	13	26
> $60,000	26	52
Mother's Highest Level of Education		
High school graduate	8	16
College graduate	25	50
Master's degree	12	24
Ph.D./J.D., M.D.	3	6
Other	2	4
Father's Highest Level of Education		
High school graduate	15	30
College graduate	16	32
Master's degree	4	8
Ph.D./J.D., M.D.	5	10
Other	10	20
	M	*SD*
Adolescent's Age at Baseline (years)	14.70	1.49
BMI percentile	60.78	29.16

Note. *M* = mean; *SD* = standard deviation; *BMI* = body mass index.
One participant did not report race/ethnicity.

Scheduled activity calendar. Research staff assisted participants in completing an activity calendar corresponding to the 20 study days. Participants were asked to report dates and times when they expected to engage in an organized exercise activity (e.g., team sports, dance practice). At the exit session participants were asked to confirm that they did, in fact, participate in an organized activity on days and times when they expected to do so, and any deviation from the scheduled exercise activity reported at baseline was recorded.

Autonomous and Controlled Motivation. The Treatment Self-Regulation Questionnaire for diet (TSRQ-D) is a 15-item scale that assesses motivation for eating a healthy diet (Levesque et al., 2007). The measure begins with *The reason I would eat a healthy diet is:* and asks responders to rate responses such as, *Because I feel that I want to take responsibility for my own health* or, *Because others would be upset with me if I did not*. Items are rated on a 7-point Likert scale including options of 1 (*not at all true)*, 4 *(somewhat true)*, and 7 *(very true).* The measure is scored with respective subscales for autonomous motivation and controlled motivation. Responses on each of the three subscales are averaged to create separate mean scores. The TSRQ-D has been found to have internally consistent subscales (α values ≥ .73; Levesque et al., 2007). In this sample, the subscales for autonomous motivation and controlled motivation were found to be highly reliable (α = .94 and .85, respectively). The TSRQ-D also had high test-retest reliability in this sample (α = .84). Previous assessments of construct validity have found the subscales of the TSRQ to correlate with respective health outcomes, with autonomous motivation correlated with perceived confidence in the ability to change one's diet (r = .54, p < .01; Levesque et al., 2007). The TSRQ-D was completed as part of the initial study visit surveys.

Hedonic Hunger. The Power of Food Scale is a 15-item measure that assesses the construct of hedonic hunger (Cappelleri et al., 2009; Lowe et al., 2009). Items assess participants' thoughts and feelings about eating, with particular attention to highly palatable foods. Response options are on a 5-point Likert scale, ranging from 1 (*don't agree at all)* to 5 *(strongly agree).* A mean of the total score was calculated, with higher scores indicating higher hedonic hunger (range 1-5). The PFS has been found to have good reliability (α = .91) and validity, correlating significantly with several measures of eating attitude and behavior (Lowe & Butryn, 2007; Lowe et al., 2009). The PFS was highly reliable in this particular sample (α = .94). The three factors represented by the PFS are *food available*, indicating the idea that food is constantly available but not physically present; *food present*, which indicates reactions to food that is present but not yet tasted; and *food tasted*, referring to palatable foods that have been tasted but not yet consumed (Lowe et al., 2009). The three factors are highly correlated and results support the use of a total scale score (Lowe & Butryn, 2007). Though the PFS has mainly been used to assess hedonic hunger in adult samples, recent data indicates that in a sample of children and adolescents, the PFS replicates the same three-factor structure, with one higher-order total score, as it has shown in adults (Cappelleri et al., 2009; Lowe et al.; 2009; Mitchell, Cushing, & Amaro, 2016). The PFS was completed once daily within the fourth survey administered through the PETE app on the smartphone.

Food consumption. The daily food consumption variables of interest were self-reported intake of high sugar, high carbohydrate, high fat, and fast foods. Therefore, the fourth smartphone survey of each day had participants indicate the number of servings of "sweet," "carbohydrate/starchy," "fatty" and "fast foods" they had eaten that day. Survey questions were adapted from items with the highest factor loadings on each food construct from a well-validated measure called the Food Craving Inventory (White, Whisenhunt, Williamson, Greenway, & Netemeyer, 2002). An example of one of these prompts is: *How many servings of SWEETS* *(foods like chocolate, cookies, cake, or candy) have you eaten today?* Participants answered *one, two, three, four,* or *five or more* to indicate their daily food consumption. Figure 2 provides an example of a daily food consumption prompt.

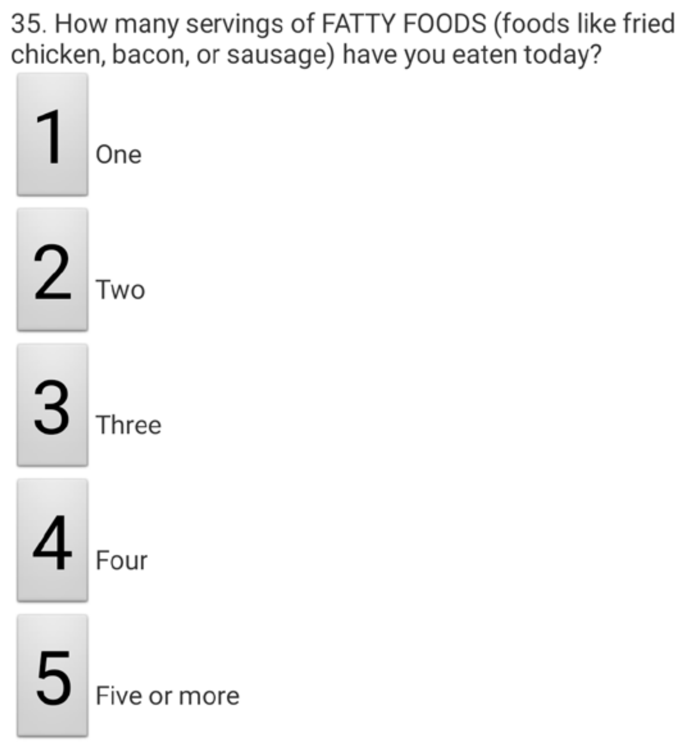


Figure 2. Example of daily survey prompt from PETE smartphone app.

Data Analysis

The current project collected intensive longitudinal data (ILD) using EMA, which was analyzed using multilevel modeling. Analyses were conducted using SAS v 9.4 (SAS Institute Inc, 2013). In addition to ILD, baseline assessment was conducted to establish time invariant levels of the constructs of interest to examine as between-person effects. Hedonic hunger was examined as both a between-persons (Level 2) and within-person (Level 1) independent variable predicting daily food consumption. Autonomous and controlled motivation were examined as between-person independent variables predicting food consumption. Two interaction terms of within-person hedonic hunger with controlled motivation and autonomous motivation, respectively, were calculated and also considered as independent variables predicting food consumption. The dependent variables, types of food consumption, were examined in terms of respective amounts of *sweet, starchy, fatty, and fast foods* eaten daily. In the case of estimating cross-level interactions, it has been recommended to use a sample of 50 participants with 20 observations each, to yield adequate power (Hox, 2002). Thus, recruitment of 50 participants for a 20-day study was appropriate. Additionally, if significant cross-level interactions were found, the results of a priori hypotheses presented here are considered to have higher power than those investigated as a result of discovering significant random slopes. Therefore, it is also acceptable to investigate specific cross-level interactions even without having found significant random slopes (Snijders & Bosker, 2012).

Data screening. Of the 1,000 expected EMA observations (one daily survey for 50 participants over 20 study days) 69.4% were fully completed by study participants (n = 694), which is lower, yet comparable to compliance rates in other EMA studies of adolescents (Brannon et al., 2016*)*. The lower rate of compliance in this study was likely due to the rigor required in screening for invalid data, and possibly due to the timing of survey administration at the end of each study day. Data were missing for two main reasons. First, 30.6% of the surveys were never started by participants. Second, on a limited number of occasions, 1.2% of the total expected EMA observations were started but not completed by participants. Data were also screened for uniform responding. Of the 1,000 total expected observations, 10.3% of cases with responses consisting of the same integer across the Power of Food Scale and food consumption items were considered invalid and counted as missing in subsequent analysis. Lastly, 3.4% of the total expected EMA observations were excluded if the survey was completed on the morning following the prompt rather than at the end of the study day. The data screening process resulted in one participant not having sufficient valid data for analysis. Following data screening 54.5% (n = 545) of expected cases were available for analysis Figure 3 provides a summary of the data screening process. Missingness was assumed to occur at random. Therefore, all data analysis was conducted using maximum likelihood (ML) estimation (Enders, 2001). While ideally no participants would be missing data, ML is preferable to other methods of handling missing data because it poses less bias to parameter estimates and has shown to be an appropriate strategy for this amount of missingness (Collins, 2001). As part of data screening, skew and kurtosis of study variables are presented in Table 2.

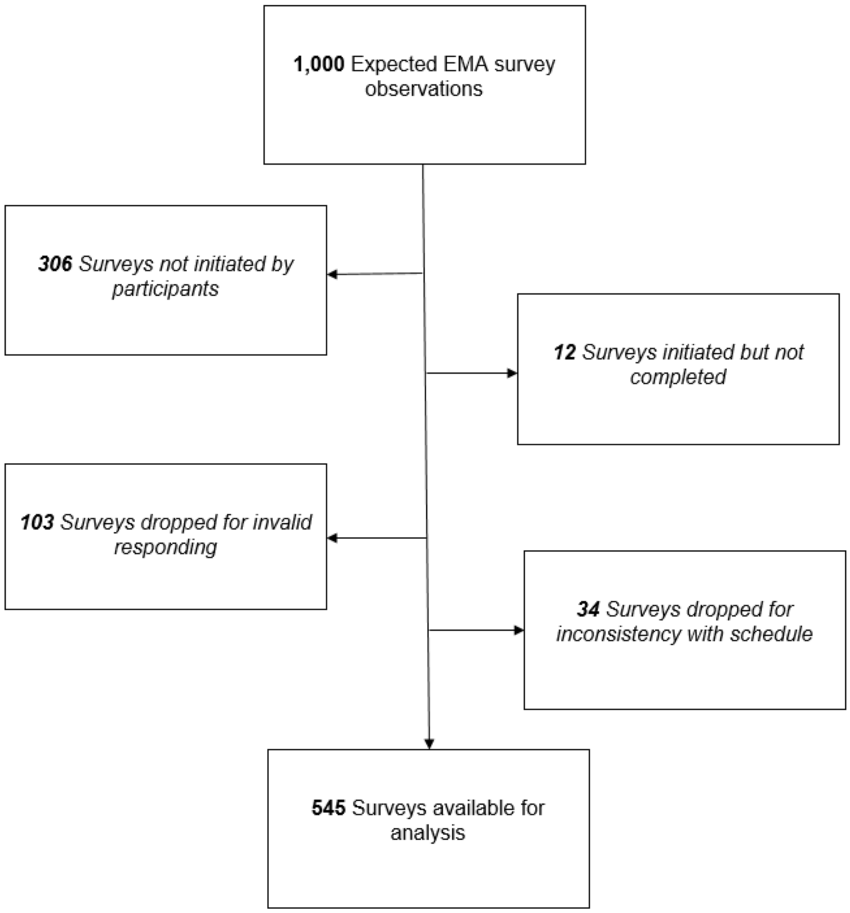


Figure 3. Flowchart summary of data screening process.

Table 2

Summary of Skew and Kurtosis of Study Variables

Variable	Skew	Kurtosis
Autonomous motivation	-.62	-.26
Controlled motivation	.03	-1.26
Hedonic hunger (Within)	.62	6.96
Hedonic hunger (Between)	1.35	1.57
Sweet	.85	.20
Starchy	.59	-.17
Fatty	1.11	.90
Fast food	1.99	3.96

Establishing within-person variability. Dependent variables were thought to vary both between and within persons. This was a testable assumption that confirmed the need for multilevel models. Each dependent variable was entered into a multilevel model with persons at Level 2 and observations at Level 1, and no predictors. An intraclass correlation coefficient (ICC) was computed using the formula ICC = (Random Intercept Variance/Total Variance)*100. This value represented the proportion of the variance that was between persons. Conversely, 100 - ICC equaled the proportion of the variance that was within persons. As there was substantial within-person variability, a multilevel model was needed.

Partitioning the variance. Once it was established that multilevel models were necessary, covariates (independent variables) were partitioned into between-person and within-person components. Between-person components consisted of the mean of each participant's responses over time. After grand-mean centering the variables, within-person variables were computed by subtracting the person mean described in the previous step from each observation (person-mean centering) resulting in a value that was relative to one's typical score on an indicator.

Modeling time. In order to evaluate how hedonic hunger performs over time (Hypothesis 1), we fit a multilevel model with a fixed linear effect of time, as well as tested alternate models (i.e., random linear, fixed quadratic, random quadratic) to determine how best to represent time in the final model. Model fit was assessed using nested model comparisons using the -2LL with significance testing using a chi-square distribution. The procedure above was repeated for all four types of food consumption (See Table 3).

Table 3

Model Comparisons for the Effect of Time

	-2 Residual Log Likelihood	Difference	df	Critical Value
DV: Sweet				
Empty Model	1538.9	--	4	9.49
Linear	1546.8	-7.9		
Random Linear	1546.5	-7.6		
Quadratic	1538.6	0.3		
Random Quadratic	1529.3	9.6		
DV: Starchy				
	-2 Residual Log Likelihood	Difference	df	Critical Value
Empty Model	1453.3	--	4	9.49
Linear	1460.2	-6.9		
Random Linear	1443.5	9.8		
Quadratic	1472.3	-19.0		
Random Quadratic	NC	--		
DV: Fatty				
	-2 Residual Log Likelihood	Difference	df	Critical Value
Empty Model	1367.9	--	4	9.49
Linear	1376.4	-8.5		
Random Linear	1346.5	21.4		
Quadratic	1385.7	-17.8		
Random Quadratic	NC	--		
DV: Fast Food				
	-2 Residual Log Likelihood	Difference	df	Critical Value
Empty Model	1245.5	--	4	9.49
Linear	1250.2	-4.7		
Random Linear	1244.3	1.2		
Quadratic	1262.4	-16.9		
Random Quadratic	1252.4	-6.9		
Variable: WP Hedonic Hunger				
	-2 Residual Log Likelihood	Difference	df	Critical Value
Empty Model	1295.2	--	4	9.49
Linear	739.6	555.6		
Random Linear	694	601.2		
Quadratic	751.3	543.9		
Random Quadratic	673.3	621.9		

Note. df = degrees of freedom. NC indicates that the model did not converge.
Critical values from Chi-square distribution. Bold text denotes best model fit.

Preliminary Analyses. To determine whether engagement in exercise contributed to consumption of more servings of food over the study days, participants were coded as "Athletes" and "Non-athletes" based on the information they provided in the scheduled activity calendar. Participants who reported engaging in at least one scheduled exercise activity were coded as "Athletes" and participants who reported having no particular physical activity scheduled were coded as "Non-athletes," and four multilevel models were run with each type of food consumption as the dependent variable.

Observations were coded for month of the calendar year in order to examine whether differences in reports of food intake differed across months of data collection. Four multilevel models were run with *sweet, starchy, fatty,* and *fast foods* as dependent variables.

Evaluating substantive hypotheses. To examine the effects of motivation and hedonic hunger, respectively, on food consumption (Hypotheses 2, 3, 4), four multilevel models were fit with each type of palatable food consumption as a dependent variable. Models were specified by adding substantive predictors to the model for time. Predictors for each model included between-person hedonic hunger, within-person hedonic hunger, between-person autonomous motivation, and between-person controlled motivation. To evaluate the proposed moderation effect (Hypothesis 5), interaction terms of within-person hedonic hunger with each motivation construct were also tested as predictors of each type of food consumption, with the expectation that the interaction between high hedonic hunger and controlled motivation would predict the most consumption of each of the four types of palatable food, and that the interaction between low hedonic hunger and high autonomous motivation would predict the least. As it is critical to evaluate simple slopes, regions of significance, and confidence bands for interactions in multilevel models, specific computational tools for post-hoc probing in multilevel modeling were used to determine the nature of any significant interactions (Preacher, Curran, & Bauer, 2006).

Results

Descriptive Statistics

Average scores of controlled and autonomous motivation could range from 1 to 7. The average level of controlled motivation for the sample was 2.93 (*SD* = 1.26, *Min:* 1.0 *Max:* 5.5) while the average reported level of autonomous motivation was 4.76 (*SD* = 1.53, *Min:* 1.0 *Max:* 7.0). Average daily levels of hedonic hunger could range from 1 to 5. The average daily level of hedonic hunger for the sample was 1.71 (*SD* = .79, *Min:* 1.0 *Max:* 4.5). Participants reported their daily serving consumption of each food category on a scale labeled 1-5. Participants reported eating on average 2.07 (*SD* = 1.05) daily servings of *sweet* foods, 2.27 (*SD* = 1.05) daily servings of *starchy* foods, 1.80 (*SD* = .93) daily servings of *fatty* foods, and 1.47 (*SD* = .84) daily servings of *fast food*.

Screening for Covariates

Descriptive statistics and bivariate correlations were conducted for the analytic sample (See Table 4). Approximate family income was significantly associated with motivation, such that participants reporting higher family income also reported higher levels of controlled and autonomous motivation. An independent samples t-test revealed that female participants reported significantly higher daily consumption of servings of *sweet* foods than male participants (female: $M = 2.15$, $SD = 1.15$, male: $M = 1.95$, $SD = .90$; $p < .05$). Additionally, male participants reported significantly higher levels of controlled motivation and higher between-person hedonic hunger than female participants. Thus, all models controlled for the variables of approximate family income and gender. Results indicated that associations with these covariates were non-significant in each of the four models (see Table 5).

Table 4

Summary of Correlations for Income, Motivation, Hedonic Hunger, and Food Consumption Variables

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*M*	*SD*
1. Approximate Family Income	--	.23**	.19**	.01	.00	-.20**	-.09*	-.08	-.18**		
2. Autonomous Motivation		--	.50**	-.04	.01	-.13**	-.13**	.05	-.19**	.005	1.53
3. Controlled Motivation			--	.02	.00	-.06	.01	.18**	-.02	-.004	1.26
4. Hedonic Hunger (Between)				--	-.00	.02	.21**	-.06	.08	.017	.69
5. Hedonic Hunger (Within)					--	.04	.05	.15**	.07	-.020	.40
6. Sweet						--	.32**	.22**	.15**	2.07	1.05
7. Fatty							--	.12**	.43**	1.80	.93
8. Starchy								--	.14**	2.27	1.05
9. Fast Food									--	1.47	.84

Note. *M* = mean; *SD* = standard deviation. Means for measures 2-5 are derived from centered variables. Measures 2-3 indicate scores on subscales of Treatment Self-Regulation Questionnaire –Diet (TSRQ-D) administered at baseline. Measures 4-5 are derived from daily reported scores on the Power of Food Scale (PFS). Measures 6-9 indicate self-reported servings of respective foods, ranging from *1 to 5 or more*.
$^*p < .05$, $^{**}p < .01$

Table 5

Associations of Predictors and Covariates with Food Consumption Dependent Variables

	Sweet		Starchy		Fatty		Fast food	
	β (SE)	*p*	β (SE)	*p*	β (SE)	*p*	β (SE)	*p*
Fixed Effects								
Intercept	1.98 (.45)	<.0001	2.52 (.59)	<.0001	2.13 (.42)	<.0001	2.08 (.41)	<.0001
Between-person								
Gender	.15 (.17)	.39	-.02 (.22)	.93	-.06 (.16)	.71	-.14 (.16)	.39
Income	-.09 (.05)	.07	-.05 (.06)	.42	-.04 (.04)	.33	-.06 (.04)	.16
BP Hedonic Hunger	.15 (.13)	.25	-.00 (.17)	.98	**.28 (.12)**	**.03**	.11 (.12)	.38
Autonomous motivation	-.05 (.06)	.46	.01 (.08)	.94	-.11 (.06)	.06	**-.14 (.06)**	**.02**
Controlled motivation	-.00 (.07)	.98	.13 (.09)	.17	.03 (.07)	.61	.07 (.07)	.30
Within-person								
Time	-.01 (.00)	.01	.01 (.01)	.48	-.00 (.01)	.87	--	
WP Hedonic Hunger	.20 (.11)	.06	**.38 (.10)**	**<.0001**	.05 (.09)	.57	.14 (.08)	.08
Cross-level Interactions								
WP Hedonic Hunger × Autonomous Motivation	.00 (.07)	.98	-.09 (.06)	.18	-.03 (.06)	.61	**-.10 (.05)**	**.05**
WP Hedonic Hunger × Controlled Motivation	.07 (.08)	.41	**.17 (.08)**	**.02**	-.06 (.07)	.34	.09 (.06)	.15
Random Effects								
(1,1)Intercept Variance	.23 (.14)	.04	.52 (.16)	.00	.37 (.12)	<.001	.20 (.06)	<.0001
(2,2)Time Slope Variance	.02 (.01)	.03	.00 (.00)	.03	.00 (.00)	.00	--	
(2,1)Intercept-Time Slope Covariance	-.03 (.03)	.27	-.01 (.01)	.12	-.02 (.01)	.02	--	
(3,3)Random Quadratic Time Variance	.00 (.00)	.04	--		--		--	
(3,2)Random Quadratic Time Slope Covariance	-.00 (.00)	.07	--		--		--	
(3,1)Intercept-Random Quadratic Time Slope Covariance	.00 (.00)	.24	--		--		--	
Residual	.78 (.06)	<.0001	.64 (.04)	<.0001	.56 (.04)	<.0001	.49 (.03)	<.0001

Note. BP = Between-Person; WP = Within-Person. Intercepts and slopes are reported from the final models for each dependent variable. Each column represents a separate model. Bold text denotes significant effects.

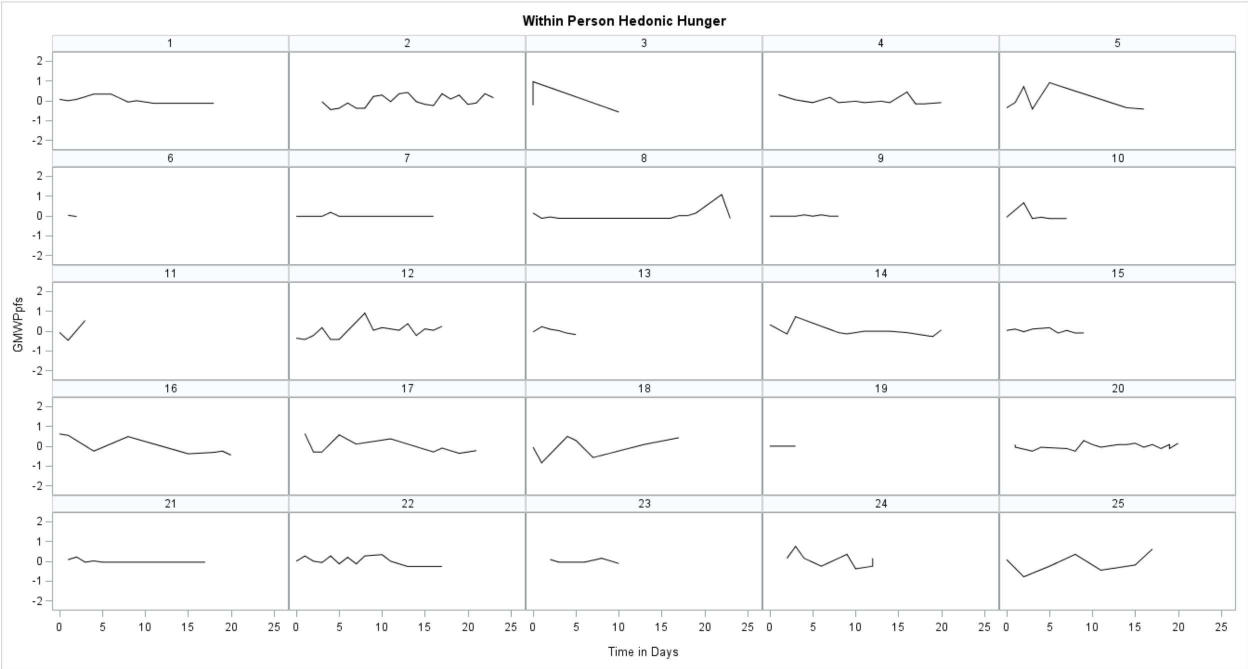
Results of Preliminary Analyses

After coding for engagement in scheduled exercise activities, 54% of participants engaged in at least one scheduled physical activity, while 46% did not engage in any particular scheduled physical activity. After establishing the effect of time, we fit a single predictor model with the dichotomous “Athlete” vs. “Non-athlete” variable predicting each type of food consumption. The results were non-significant, and therefore the variable was not included in subsequent models.

Observations obtained from participants occurred from June through February of the following year. A model was fit with month of year predicting each type of food consumption. Results were also non-significant; therefore, this variable was not included in subsequent models.

Variability, Effects of Time, and Associations with Dependent Variables

Hedonic hunger. The ICC for hedonic hunger was 66.72, suggesting that 66.7% of the variability was between-person, and that 33.3% of the variability was within-person. As explained in the data analysis plan, models for time were compared for each dependent variable. A random quadratic effect of time was established for the hedonic hunger variable, indicating that hedonic hunger plateaued randomly for individuals across the study period (see Figure 4).



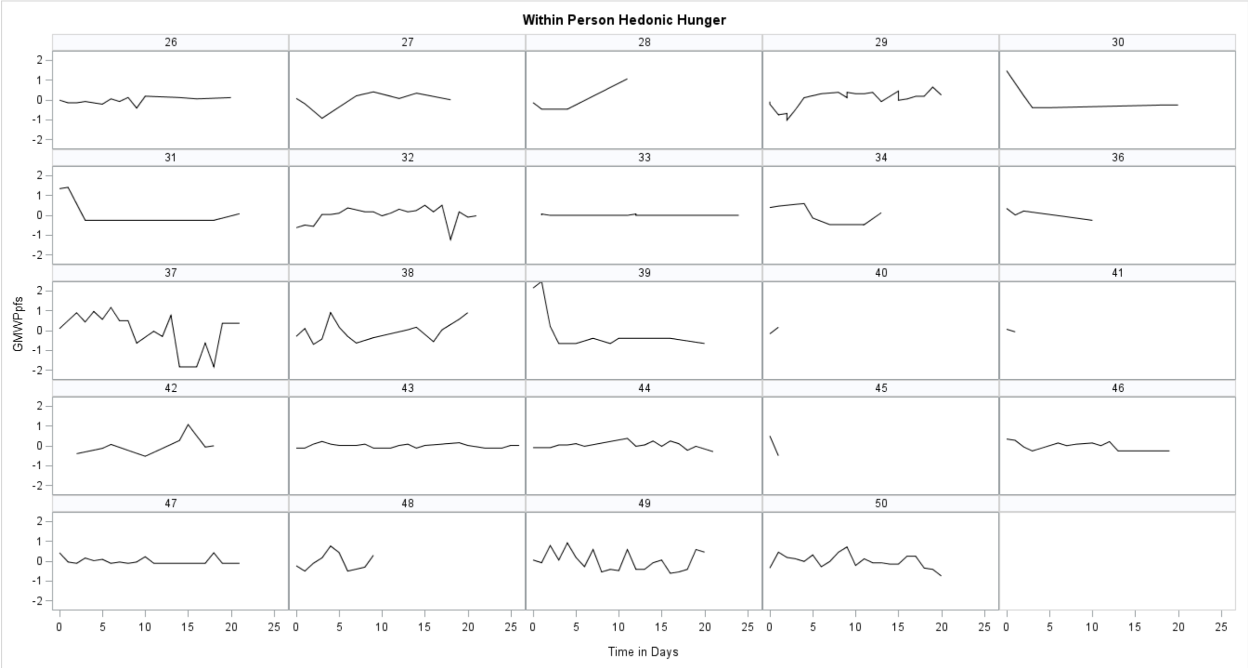


Figure 4. Variations in hedonic hunger for each participant over duration of study.
Note: Participant 35 did not provide sufficient valid data to display variation in hedonic hunger.

Sweet food consumption. The ICC for the *sweet* dependent variable was 21.35, suggesting that 21.4% of the variability was between-person, and therefore, 78.7% of the variability was within-person. The intercept for the empty model was 2.01.

A random quadratic effect of time was established for the dependent variable of *sweet* food consumption. No significant associations were found between the independent variables and *sweet* food consumption, and no significant interactions were found.

Starchy food consumption. The ICC for the *starchy* food dependent variable was 34.46, suggesting that 34.5% of the variability was between-person, and therefore, 65.5% of the variability was within-person. The intercept for this variable in the empty model was 2.26.

A random linear effect of time was established for the dependent variable of *starchy* food consumption. Within-person hedonic hunger was positively associated with consumption of *starchy* foods ($\beta = .38$, $p < .0001$), such that individuals experiencing higher hedonic hunger than they typically experienced reported consuming more servings of *starchy* foods.

The interaction term of within-person hedonic hunger and controlled motivation was also positively associated with *starchy* food consumption ($\beta = .17$, $p < .02$). Results of probing significant interactions to interpret the conditional effects indicated that, as hedonic hunger increased, the slope relating controlled motivation to starchy food consumption become more strongly positive (See Figure 5). At the conditional value of hedonic hunger one standard deviation below the mean, the simple slope was .06 (p =.55, not significant). At the mean of hedonic hunger, the simple slope was .13 (p = .17, not significant). At the conditional value of hedonic hunger one standard deviation above the mean, the simple slope was .20 (p = .04, significant), indicating that controlled motivation was a significant predictor of consumption of more servings of *starchy* foods, at higher levels of hedonic hunger. The region of significance for the moderator (hedonic hunger) ranged from -5.42 to .35, indicating that any given simple slope outside of this range was statistically significant. Given that the centered within-person hedonic hunger variable had a mean of -.02 and a standard deviation of .40, this indicated that the effect of controlled motivation on *starchy* food consumption was significant only for relatively high observed values of hedonic hunger.

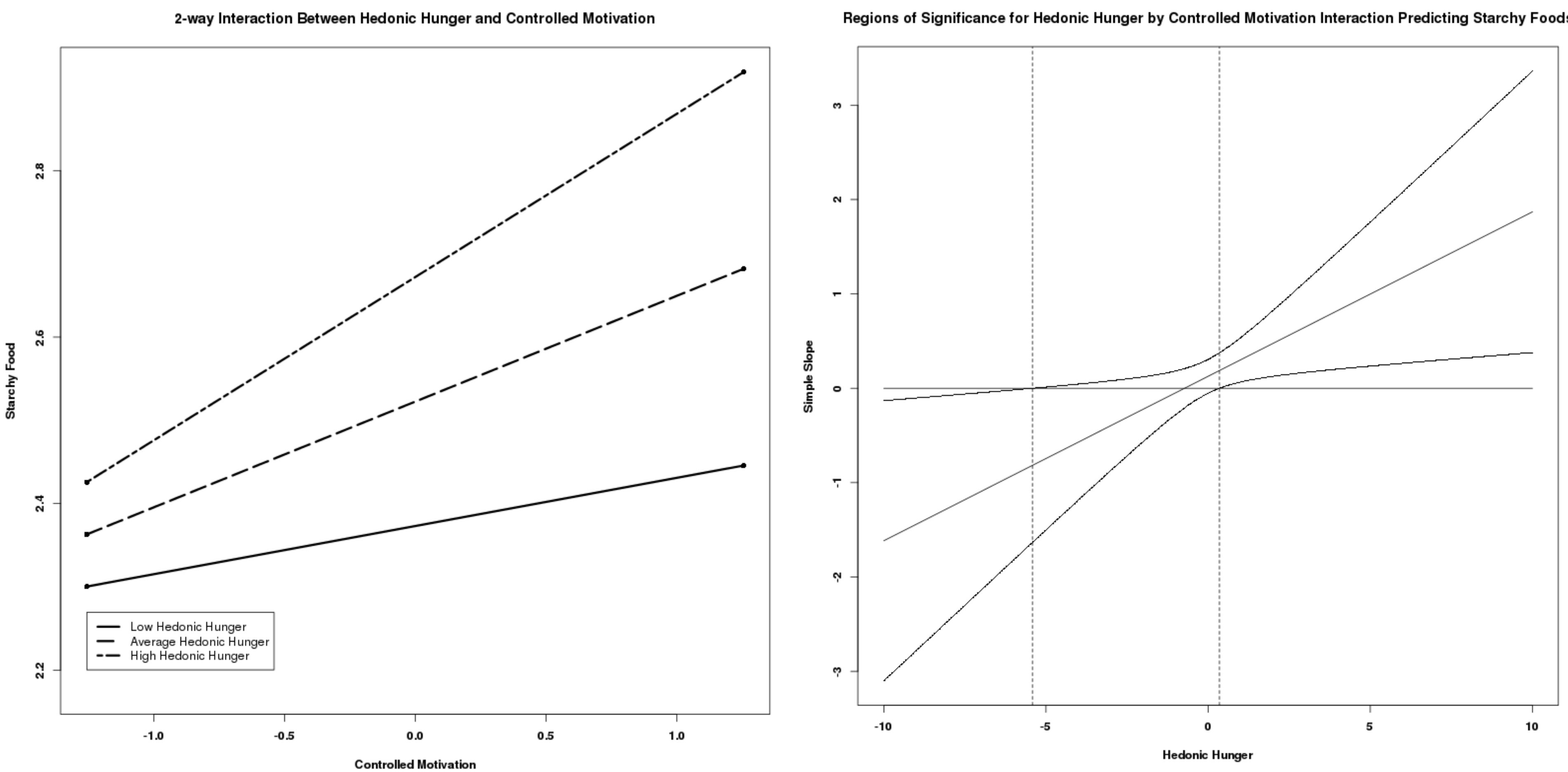


Figure 5. Mean plot illustrating the interaction of controlled motivation and hedonic hunger predicting starchy food consumption (left). The interaction was significant for "High Hedonic Hunger."Plot illustrating confidence bands for observed sample values of hedonic hunger (right). Simple slopes are significant outside of -5.42 to .35 bounds.

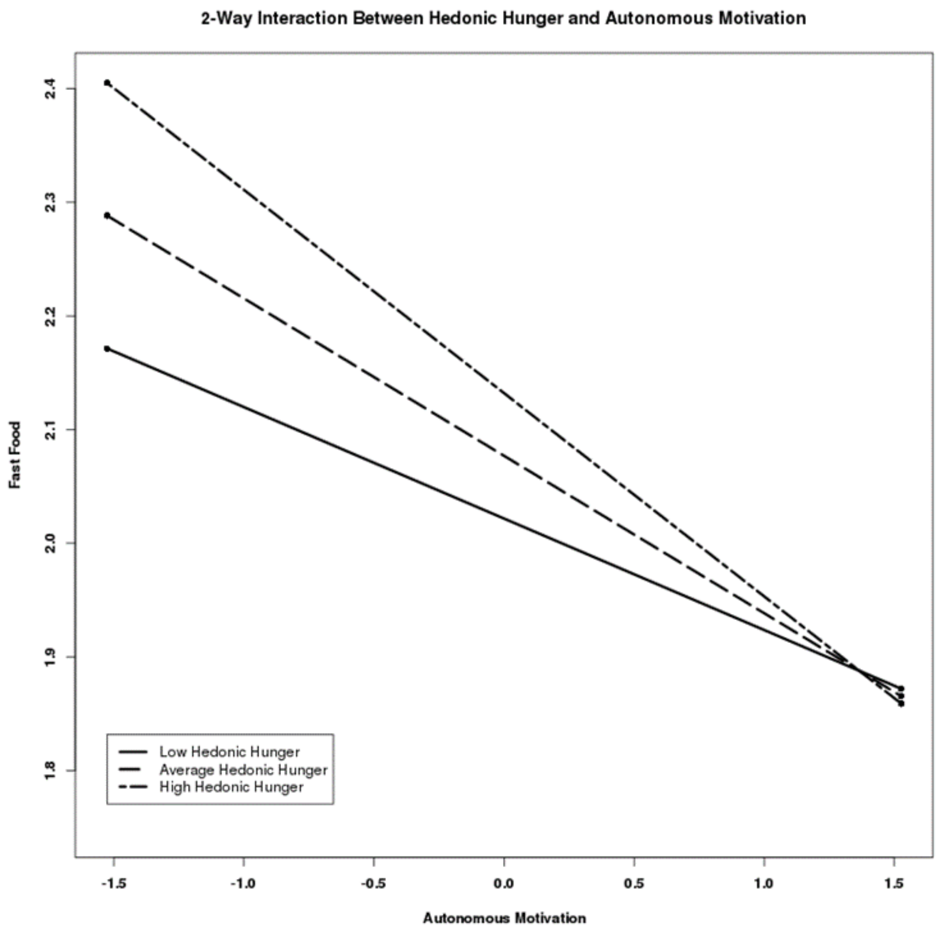
Fatty food consumption. The ICC for the *fatty* food dependent variable was 27.51, suggesting that 27.5% of the variability was between-person, and therefore, 72.5% of the variability was within-person. The intercept for the empty model was 1.73.

A random linear effect of time was established for the dependent variable of *fatty* food consumption. Between-person hedonic hunger was positively associated with consumption of *fatty* foods (β = .28, p = .03), such that individuals who reported higher levels of hedonic hunger than others also reported consuming more servings of *fatty* foods. No significant interactions were found to be predictors of *fatty* food consumption.

Fast food consumption. The ICC for the *fast food* dependent variable was 31.75, suggesting that 31.8% of the variability was between-person, and therefore, 68.3% of the variability was within-person. The intercept for the empty model was 1.46.

For the *fast food* consumption variable, none of the alternate models for time fit better than the empty model. Autonomous motivation was negatively associated with consumption of *fast foods* (β = -.14, p = .02).

Additionally, the interaction term of within-person hedonic hunger and autonomous motivation was negatively associated with *fast food* consumption (β = -.10, $p < .05$). Results of probing significant interactions to interpret the conditional effects indicated that, as hedonic hunger increased, the slope relating autonomous motivation to *fast food* consumption became more strongly negative (see Figure 6). At the conditional value of hedonic hunger one standard deviation below the mean, the simple slope was -.10 (p =.11, not significant). At the mean of hedonic hunger, the simple slope was -.14 (p = .02, significant). At the conditional value of hedonic hunger one standard deviation above the mean, the simple slope was -.18 (p = .004, significant), indicating that autonomous motivation was a significant predictor of consumption of fewer servings *of fast foods*, at average or higher levels of hedonic hunger. The region of significance for the moderator (hedonic hunger) ranged from -.22 to 420.79, indicating that any given simple slope outside of this range was statistically significant.



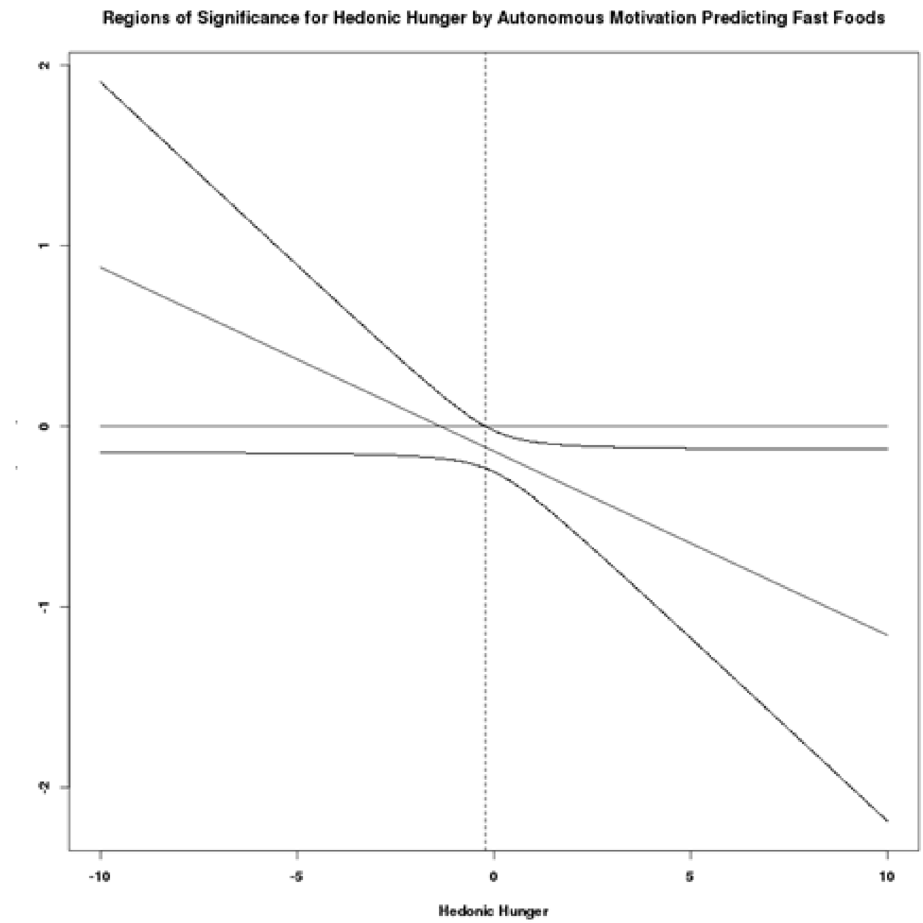


Figure 6. Mean plot illustrating the interaction of autonomous motivation and hedonic hunger predicting fast food consumption (left). The interaction was significant for "Average Hedonic Hunger" and "High Hedonic Hunger." Plot illustrating confidence bands for observed sample values of hedonic hunger (right). Simple slopes are significant outside of -.22 to 420.79 bounds.

Discussion

The present study aimed to determine whether hedonic hunger functions as a state or trait construct and to examine dietary motivation and hedonic hunger as predictors of adolescents' consumption of specific types of palatable food. The first hypothesis was supported, as hedonic hunger did, in fact, demonstrate both state and trait properties (66.7%, between-, 33.3% within-person variability). The between-person variability helps to explain why lab-based protocols are able to detect the effect of hedonic hunger at the group level with a single observation (Appelhans et al., 2011; Ely, Howard, & Lowe, 2015; Witt et al., 2014). The within-person variability observed in the current study answers calls to examine hedonic hunger as a temporally fluctuating variable, and highlights the importance of including within-person conceptualizations of the construct in future research protocols (Boggiano et al., 2015; Thomas et al., 2011).

Additionally, hypothesis 2 was partially supported with data indicating that between-person hedonic hunger predicted *fatty* food consumption and within-person hedonic hunger predicted *starchy* food consumption. This indicates that adolescents' consumption of palatable food may be differentially influenced by whether hedonic hunger is conceptualized as a state or trait variable. That is, adolescents who experience higher hedonic hunger than their peers are more likely to consume *fatty* foods, which aligns with previous research associating hedonic hunger with higher unhealthy snack intake in adolescents (Stok et al., 2015). Our results suggest that hedonic hunger may be a useful variable for determining which adolescents within a given population are at risk for consuming *fatty* foods, and may benefit from intervention. On the other hand, the current findings suggest that any adolescent, regardless of how their hedonic hunger compares to their peers, may be susceptible to consumption of *starchy* food when they experience a spike in their own hedonic hunger. Some researchers have begun to assess the food environment through EMA protocols (Thomas et al., 2011) but this is the first known study to examine within-person fluctuations in hedonic hunger as predictive of food intake. Therefore, results of the present study contribute to the literature, indicating that future investigations may need to conceptualize hedonic hunger as a trait variable subject to within-person fluctuation to cover the range of dietary influences exerted by the construct.

The third hypothesis was also partially supported, with results indicating that autonomous motivation was negatively related to consumption of *fast foods*. This fits with self-determination theory and the current literature on dietary motivation which suggests that intrinsic motivation to consume a healthy diet is associated with healthier food choices and the ability to resist unhealthy foods (Hartmann, Dohle, & Siegrist, 2015; Ryan, Patrick, Deci, & Williams, 2008; Stok et al., 2015). Regarding the effect of the interaction between autonomous motivation and within-person hedonic hunger, the significant interaction predicting *fast food* consumption was not entirely consistent with hypothesis 5, as the interaction was significant at mean and higher levels of hedonic hunger, rather than low levels. This suggests that adolescents with high intrinsic motivation to consume a healthful diet may be able to resist the influence of hedonic hunger, even when it is higher than usual, and still ultimately consume fewer servings of fast food. In fact, these findings suggest that as hedonic hunger trends higher the protection offered by autonomous motivation becomes stronger. Results from a qualitative study align with this finding, in that adolescents expressed opinions about taking more autonomous responsibility for healthy food choices after having experienced incidents where fast food made them feel ill or negatively affected their functioning (Bassett, Chapman, & Beagan, 2008). While this finding was not exactly as hypothesized, it provides valuable information suggesting that while autonomous motivation appears to prevent consumption of palatable *fast food*, fluctuations in hedonic hunger are important drivers of behavior among adolescent with low autonomous motivation for a healthy diet.

Findings were inconsistent with the fourth hypothesis, as controlled dietary motivation was not a significant predictor of any of the palatable food consumption. According to the self-determination theory literature, it is possible that controlled motivation may not always directly lead to choices that negatively impact health, but that the choices driven by controlled motivation may not foster the same satisfaction or feeling of worth as compared to actions driven by autonomous motivation (Deci & Ryan, 2008). Therefore, though controlled dietary motivation did not predict consumption of palatable foods, the effects associated with adolescents' extrinsically driven dietary choices merit further attention. Specifically, controlled motivation and within-person hedonic hunger interacted to predict *starchy* food consumption, which was consistent with hypothesis 5 and provided support for within-person hedonic hunger as a moderator. Adolescents with high controlled dietary motivation who also experienced higher hedonic hunger than was typical for them reported consuming more servings of *starchy* foods. This suggests that adolescents with externally motivated reasons for consuming a healthful diet may be more vulnerable to the influence of hedonic hunger, and may then consume more servings of *starchy* foods. This significant finding predicting *starchy* food intake, but not *sweet, fatty,* or *fast food,* is similar to that of another study which found associations between high hedonic hunger and consumption of plain oatmeal, but not palatable sweet and savory snack foods (Ely, Howard, & Lowe, 2015). This finding helps identify the specific combination of controlled dietary motivation and high within-person hedonic hunger as a factor that may contribute to consumption of palatable *starchy* foods.

To summarize, the moderation effects of hypothesis 5 were partially supported, as within-person hedonic hunger moderated the respective relationships between controlled motivation and *starchy* food consumption, and the relationship between autonomous motivation and *fast food* consumption. A combination of variables similar to those in the present study were examined by Stok et al. (2015) in one existing study of adolescents, and found that self-regulatory competence (i.e. the ability to resist an immediate temptation in order to remain aligned with a long-term goal; Vohs & Baumeister, 2011) attenuated the influence of hedonic hunger on consumption of unhealthy snacks, in that the interaction of high hedonic hunger and high use of self-regulation predicted consumption of fewer unhealthy snacks. Findings from the present study align with those of Stok and colleagues, with the added novelty of considering the effects of adolescents' individual time-varying fluctuations in hedonic hunger as well as using the variables of interest to predict consumption of particular types of palatable foods. Results of our study confirm the importance of dietary motivation as indicated by prior studies (Levesque et al., 2007; Niermann, Kremers, Renner, & Woll, 2015), and contributes evidence that hedonic hunger is also a significant time-varying factor that may account for choices in food consumption. The significant multilevel interactions confirm that unique relationships exist between trait dietary motivation and fluctuating hedonic hunger, and that the interactions of these variables on an individual level may hold value in understanding and addressing unhealthful dietary choices (i.e. eating palatable foods in excess).

Clinical Implications

The support for dietary motivation and hedonic hunger as predictors of food intake have clinical implications for adolescents' psychological and physical health. Overall, adolescents with high controlled motivation may be vulnerable to the influence of high hedonic hunger, and thus especially prone to eating higher quantities of starchy foods. Findings also highlight the value of autonomous motivation as a trait that may inhibit adolescents' consumption of fast foods, beyond fluctuations in hedonic hunger. However, adolescents who do not have strong autonomous motivation for a healthful diet may be particularly vulnerable to the experience of hedonic hunger, and at high risk for consuming more fast food.

Findings also highlight the independent respective natures of autonomous and controlled motivation. The effects found in this study with regard to the motivation variables provide further confirmation that each of these motivation constructs functions uniquely, and should be studied accordingly. Autonomous motivation appears to be particularly vital, as our findings indicate that having higher autonomous motivation than peers may contribute to decreased vulnerability to fast food consumption regardless of hedonic hunger. Stated another way, adolescents may be capable of resisting the influence of hedonic hunger for fast food most of the time if they hold strong intrinsic motivation to eat a healthy diet. It is possible that having autonomous motivation for a healthy diet would protect an adolescent from engaging in a deliberate and planned unhealthy behavior (e.g. taking a drive to purchase fast food), even when he or she is experiencing high hedonic hunger. In contrast, the interaction effect may not be present for other food types because they may be readily available in an adolescent's home or school, and more subject to impulsive consumption. While dietary motivation does not appear to fluctuate rapidly, there exists some evidence that novel clinical strategies may allow for shifts in motivation constructs over extended periods of time. For example, as mindfulness has been shown to play a role in development of autonomous regulation and motivation (Deci & Ryan, 2008), clinical exercises to promote mindful eating strategies may be useful (Dalen, Brody, Staples, & Sedillo, 2015; Forman & Butryn, 2015). Clinical efforts for health promotion and prevention could also encourage autonomous motivation through nutrition education to understand the impact of dietary choices on one's own health and well-being as a means of decreasing fast food consumption. With regard to fatty and starchy foods, autonomous motivation does not appear to serve as a protective factor. Therefore, stimulus control efforts such as removing these foods from the home, storing them in infrequently accessed locations, and avoiding purchasing them at the store are likely to be helpful intervention strategies.

Limitations

One limitation of the present study was the use of self-reported food consumption data. Though most methods of measuring food consumption are subject to limitations, such as social desirability, reactivity, and accuracy in reporting serving size, use of an additional measure to validate self-reported data is recommended and adds substantial value to dietary data (Subar et al., 2015). Additionally, while the food consumption categories were derived from a well-validated measure, there may have been inconsistencies amongst adolescents regarding how some foods were categorized. Although survey items instructed adolescents in how to categorize food consumption, it is possible that the particular categories of *sugary* and *starchy* overlapped, and that the categories of *fatty* and *fast food* overlapped. Adolescents were provided examples of three foods in each category, but may have been unsure of how to categorize foods outside of these examples, potentially leading to variation among adolescents' categorization of certain foods. For example, a participant having eaten a cinnamon roll could have reasonably counted it as serving(s) of *sweet* food (described as "foods like chocolate, cookies, cake, or candy") while another participant may have counted it as starchy (described as "foods like cereal, sandwich bread, or rolls").

Another limitation regarding self-report of hedonic hunger and dietary motivation, in addition to food consumption, is the potential for socially desirable responses. Past studies have shown social desirability to reduce accuracy of self-reported dietary intake in college students and adults (Schoch & Raynor, 2012; Tooze et al., 2004). For example, participants may have considered endorsement of autonomous dietary motivation as more desirable or respectable, felt hesitant to report high levels of hedonic hunger, or underreported servings of palatable food consumed. However, some data suggests that less social desirability bias may be present when respondents have more flexibility to choose the location in which they answer survey questions (Lynn & Kaminska, 2012). The fact that most observations of the variables (i.e. hedonic hunger and food consumption over 20 study days) occurred through remotely administered smartphone surveys may have decreased the likelihood of socially desirable responding, as compared to completing measures in close proximity to a member of the research staff.

Lastly, homogeneity of the sample limits generalizability of the present study's findings. Though recruitment efforts were made to reach adolescents in a variety of contexts in order to yield a diverse sample with respect to gender, race, and family socioeconomic status, the resulting sample was predominantly Caucasian and upper middle class.

Conclusions and Future Direction

The present study enhances current knowledge about the function of hedonic hunger as a variable through evidence that it does vary over time and includes substantial between- and within-person variability. Future studies may examine more closely examine fluctuations in hedonic hunger by testing whether it changes at different times of day or in relation to an individual's daily experiences and previous food consumption. Moreover, this study presents a novel investigation of the relationship between trait dietary motivation and time-varying hedonic hunger, which were found to predict palatable food consumption. While findings about the association between BMI and hedonic hunger have been mixed (Carpenter, Wong, Li, Noble, & Heber, 2013; Mitchell, Cushing, & Amaro, 2016; Schultes, Ernst, Wilms, Thurnheer, & Hallschmid, 2010), now that the initial relationships between state and trait hedonic hunger have been investigated, a larger study with appropriate stratification of BMI may include weight status as a predictor variable.

It is recommended that future studies continue to examine adolescents' dietary behavior with more advanced measures of food consumption, such as three-day dietary recall (Subar et al., 2015), as well as examine these particular relationships in more diverse samples. Future research should also continue to examine hedonic hunger as both a between- and within-person variable, and seek to determine whether the respective uses of the variable differentially predict various dietary choices.

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