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ECOLOGICAL MOMENTARY ASSESSMENT AND TIME-VARYING FACTORS ASSOCIATED WITH EATING AND PHYSICAL ACTIVITY

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ECOLOGICAL MOMENTARY ASSESSMENT AND TIME-VARYING FACTORS ASSOCIATED WITH EATING AND PHYSICAL ACTIVITY

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University

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Abstract

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The obesity epidemic is a significant problem in the United States. It is well established that lifestyle factors, such as unhealthy eating and physical inactivity, are key contributors. These causes are generally voluntary activities and it is important to examine health decision-making with respect to these behaviors. The current study examined time-varying factors of stress and mood and their relationship with healthy eating and physical activity in a sample of undergrads ($N = 26$). Ecological momentary assessment via one's cell phone was used to collect multiple measurements over six days. Positive mood was found to follow physical activity episodes for up to five hours, and preceded physical activity for up

until five before the activity occurred. These results are consistent with those from previous literature, and suggest a clear association between positive mood and physical activity. Future research should incorporate more objective measures of physical activity and eating.

Ecological Momentary Assessment and Time-Varying Factors Associated with Eating and Physical Activity

Prevalence of Obesity

Obesity and its associated health problems are a major public health concern. Data from the Centers for Disease Control and Prevention suggest a remarkable increase over the past twenty years in obesity (CDC, 2012a). Since 1980, adult obesity rates have doubled and rates for children have tripled. According to data from the 2009-2010 National Health and Nutrition Examination Survey, more than one-third of adults and almost 17% of children and adolescents are obese (CDC, 2012b). Furthermore, no U.S. states met the national Healthy People 2010 goal to reduce the prevalence of obesity to 15 percent; in fact, every state had an obesity prevalence of greater than 20 percent in 2010 and 12 states had a prevalence of 30% (CDC, 2012c).

Consequences of Obesity

Obesity is the second leading underlying contributor to premature death, and is associated with some of the leading killers in the United States (e.g., heart disease, diabetes, cancer, hypertension, pulmonary and renal problems, etc.) (National Heart, Lung, and Blood Institute; Kopelman, 2007). Aside from the physical risks, there are also mental health risks of obesity. Many obese people are often stigmatized (Ebneter, Latner, & O'Brien, 2011). It is not uncommon for people with obesity to manifest signs of distress, anxiety, or depression (Kelly, Daniel, Dal Grande, & Taylor, 2011). Both the physical and mental health consequences of obesity can be detrimental to an individual.

Obesity is also important from an economic standpoint. In 2008 dollars, healthcare costs of obesity totaled about $147 billion (Finkelstein, Trogdon, Cohen, & Dietz, 2009).

These medical costs involve both direct and indirect costs. Direct costs include preventive, diagnostic, and treatment services that are related to obesity (Finkelstein et al.). Indirect costs include lost income from a decrease in productivity, restricted activity, and days absent from work and loss of future income that is attributed to premature death (Finkelstein et al.).

Causes of Obesity

A variety of factors can contribute to the onset of obesity. However, some of the most important causes are related to behavioral, environmental, and genetic factors. Some genes can contribute directly to obesity (Kopelman, 2007; CDC, 2011). The interaction of multiple genes can increase a person's susceptibility (Kopelman; CDC, 2011). Oftentimes, these genes are expressed when triggered by outside factors, such as environmental influences (Kopelman; CDC, 2011). Some people have argued that we live in an increasingly "obesogenic" environment that promotes weight gain due to an increase of unhealthy foods (e.g., fast-food) and physical inactivity (e.g., increased computer time) (CDC, 2011). Although genes can play a role, lifestyle choices and the environment significantly influence obesity.

Unhealthy Eating. Unhealthy eating is one lifestyle factor that contributes to obesity. When examining risk factors in overweight women, Sanchez and colleagues (Sanchez, Norman, Sallis, Calfas, Rock, & Patrick, 2008) found that approximately 76% of the women exceeded dietary fat guidelines and 79% did not meet the minimum recommendations for fruit and vegetable consumption. In a large sample of overweight and obese adults, participants with higher BMIs reported less healthy eating behaviors (Kushner & Choi, 2010). The most common unhealthy eating behavior that emerged in the two highest BMI categories was consuming large portion sizes. The next most common unhealthy behavior in

the highest BMI category was constant snacking. Consumption of frequent meals, eating energy dense foods, and low fiber intake are also been associated with a heightened risk of overweight or obesity (Beydoun, Powell, & Wang, 2008). A negative correlation was demonstrated between BMI and consumption of grains, vegetables, fibers, and beans (Abdel-Megeid, Abdelkarem, & El-Fetouh, 2011). Ma and colleagues (Ma, Bertone, Stanek III, Reed, Hebert, Cohen, Merriam, & Ockene, 2003) found that higher rates of skipping breakfast and eating breakfast and dinner away from home were related to an increase in obesity prevalence. Unsurprisingly, fast food consumption is positively correlated with BMI (French, Harnack, & Jeffery, 2000; Binkley, Eales, & Jekanowski, 2000).

Physical Inactivity. Physical inactivity is another contributor to the obesity epidemic. Today's growing obesogenic environments support sedentary lifestyles (French, Story, & Jeffery, 2001). Sedentary activities include television viewing, computer use, and video game playing. These popular leisure-time activities are often regarded as a critical contributing factor to the decline in physical activity (French, Story, & Jeffery). Environments that are not conducive to activities such as walking or biking are also associated with higher BMIs. In Sanchez and colleagues' (2007) study concerning risk factors in overweight women, 74% of the sample failed to meet the daily recommended physical activity guidelines. Research has shown a negative correlation between BMI and exercise (Abdel-Megeid et al., 2011). Compared to normal-weight peers, overweight and obese college students reported less physical activity (Desai, Miller, Staples, & Bravender, 2008). Bassett Jr. and colleagues (Bassett, Jr., Wyatt, Thompson, Peters, & Hill, 2010) found that BMI was negatively associated with physical activity as measured by pedometer-use in adults.

Health Decision-Making

Unhealthy eating and physical inactivity are two key causes of obesity. Engaging in physical activity and eating healthy foods are generally voluntary activities. Therefore, it is necessary to examine decision-making concerning these behaviors. These activities differ somewhat from other health behaviors in that they are not characterized by single-event decision-making, such as dental check-ups (Dunton & Atienza, 2009). Deciding whether or not to engage in such activities is a process, similar to adherence to antiretroviral drugs for treatment in HIV (Griffiths, Miles, Aldam, Cornforth, Minton, Edwards, & Williams, 2007). Throughout the course of a day, an individual may encounter multiple times in which a decision is made to either engage or not to engage in physical activity and/or healthy eating. Many factors play a role in decision-making, and these factors are subject to change from one moment to the next.

Interindividual Versus Intraindividual Processes

There are two primary ways in which people have examined the relationships between psychological variables and health behaviors: interindividually and intraindividually. There is an abundance of research on interindividual processes (Dunton & Atienza, 2009). This approach examines why one person is more likely to practice a particular behavior over another individual (Dunton & Atienza). This is the commonly used between-subjects model. For example, Raynor and Levine (2009) examined the relationship between health behaviors and personality factors. College students had to fill out a one-time survey assessing these variables. Results indicated that individuals high in conscientiousness were more likely to wear seat belts, exercise, get adequate sleep, and eat more fruits and vegetables. Individuals high in extraversion had a greater propensity towards smoking cigarettes, drinking alcohol, and having multiple sex partners. While these are important

findings, results highlighted differences between people and did not account for variability within individuals and across situations. Alternately, intraindividual processes are based on within-subject models that take individual variability into account across relevant contexts (Cervone, 2005). An implication of an intraindividual focus is that individual differences are more than mean response tendencies, such that people tend to exhibit patterns of variability across contexts (Vansteelandt & Van Mechelen, 2004). As just one example, Shiffman and colleagues (Shiffman, Balabanis, Gwaltney, Paty, Gnys, Kassel, Hickcox, & Paton, 2007) examined predictors of first lapse during smoking cessation in real-world and real-time contexts. Participants in a smoking cessation study first completed two baseline questionnaires of negative affect smoking. These global measures did not predict first lapse. However, when participants reported on various moods and activities each time they smoked and at randomly selected non-smoking times via an electronic diary, negative affect did predict first lapse. Within-individual differences in negative affect assessed in real-world contexts were the only significant predictor of first lapse. Neither of the one-time administered surveys was significant in predicting smoking patterns (thus, interindividual differences in negative affect were not predictive of relapse but within-individual differences were). Thus, the real-time assessment of negative affect was the only significant predictor. One can see that these two methods can lead to different conclusions, which confirms the importance of examining individual differences in real-world and real-time contexts.

Interindividual Health-Related Research

First, I will describe health-related research from the context of an interindividual examination highlighting work related to obesity. Following that, I will highlight research focusing on an intraindividual perspective.

Health Behavior Theories. Most notable health behavior theories focus on interindividual processes (Dunton & Atienza, 2009). For example, the Theory of Planned Behavior examines whether an individual engages in a certain behavior based on attitudes toward the behavior, subjective norms, perceived behavioral control, and intentions (Ajzen, 1991). Similarly, the Health Belief Model posits that health-related actions concerning a disease or negative health outcome are dependent upon an individual's perceived susceptibility, severity, barriers, benefits, and self-efficacy (Rosenstock, Strecher, & Becker, 1988).

Health-Related Research. Much of the other health-related research in the field also places an emphasis on interindividual differences. In 2006, Rhodes and Smith conducted a review of the literature examining personality traits and physical activity. They looked at 33 studies from 1969-2006, all of which examined these factors by looking at interindividual differences. Findings identified extraversion, neuroticism, and consciousness as correlates of physical activity. In 2002, Trost and colleagues (Trost, Owen, Bauman, Sallis, & Brown) conducted a systematic review of the literature regarding multiple factors associated with physical activity, with most research relying on cross-sectional studies. Some of the results included: a positive association between physical activity and social support, a healthy diet, and physical activity self-efficacy; physical activity was inversely associated with obesity, smoking, and lack of time. Using a cross-sectional study, Trost and colleagues (Trost, Kerr, Ward, & Pate, 2001) found that obese children reported less time spent in physical activity and lower physical activity self-efficacy. In 2002, Boutelle and colleagues (Boutelle, Neumark-Sztainer, Story, & Resnick) found that overweight adolescents engage in more unhealthy weight loss strategies and do not endorse healthier strategies, such as increasing

physical activity or eating healthier. In a cross-sectional study examining nutritional knowledge, attitudes regarding the consumption of dietary fat, and actual dietary fat intake among males, a significant difference was found between people with varying attitudes toward decreasing fat and actual fat intake (Packman & Kirk, 2000). Participants in the low fat consumption group had more positive attitudes towards the benefits of decreasing fat intake and regarding the ease with which this could be implemented in their diet.

Intraindividual Processes

In contrast to the abundant research on interindividual variability, research on intraindividual processes is lacking. There is increasing support that these processes can aid in the understanding of how human behavior changes over time (Dunton & Atienza, 2009). Researchers have noted that a better way to make advances in the area of psychological processes is to understand that there are two processes to examine: interindividual and intraindividual differences (Cervone, 2005). In 2002, Ghisletta, Nesselroade, Featherman, and Rowe demonstrated that intraindividual variability of health ratings and social activity behaviors was superior in predicting mortality over interindividual differences in the mean scores on health ratings and social activity behaviors. Participants (ages 56-88) were residents in a retirement community. They completed three health self-report items and six items measuring social activities. Researchers assessed participants' health ratings and social activity behaviors weekly for 25 weeks. Means on health and social activity measures were interpreted as interindividual differences, while the standard deviations represented differences in intraindividual variability. Five and a half years after the assessments were taken, three predictors were found to be significant in predicting mortality: program attendance rate of the last week of measurements (i.e., attend clubs or organizations), and the

standard deviations of both health status and own health rating. The standard deviations of these latter two health measures were able to predict mortality whereas their mean scores were not. If intraindividual differences had not been examined, only program attendance rate of the last week would have been significant in predicting mortality. Despite little attention in the literature, one can see the importance of intraindividual variability and how it is especially relevant to health behaviors.

Importance of Time-Varying Factors

To understand the causes of physical inactivity and unhealthful eating more completely, it is important to examine these activities within the individual. As stated previously, these activities are dependent upon many thought processes and decision-making throughout the day. Many of these influential factors change throughout the course of a day, and it is essential to examine an individual's responses to such changes (Dunton & Atienza, 2009). There is little research on time-varying factors (also known as temporal effects) that might explain diet and exercise behaviors within an individual (Dunton & Atienza). It may be that these factors contribute more to whether a person engages in a behavior or not, compared with stable characteristics, such as personality. Temporal effects may be of particular importance with respect to assessing the contexts surrounding healthful decision-making concerning diet and exercise. Such temporal associations can help explain the kinds of events and experiences that precede and follow these activities (Dunton & Atienza). Currently, however, little research on temporal effects has been done. In fact, much of the research is based on cross-sectional data, which does not permit temporal associations.

Interindividual Research and Factors Associated with Obesity

Mood and Food Consumption. One variable associated with decision-making throughout the day is mood. When examined from an interindividual perspective, mood has been associated with many health-relevant behaviors (Fedorikhin & Patrick, 2010; Salovey & Birnbaum, 1989; Jones, O'Connor, Conner, McMillan, & Ferguson, 2007) including food consumption and eating behaviors. In a sample of undergraduates, positive affect was related to eating more healthy foods (Griffin, Friend, Eitel, & Lobel, 1993). In Fedorikhin and Patrick's study on the association between positive mood and resisting temptations that interfere with health goals, food consumption was used to examine resistance to temptation. Participants in a positive mood were more likely to choose a healthy option (grapes) over a less healthy option (M&M's). Likewise, negative affect has been associated with an increased consumption of snacks both high in fat and sugar among men (Jones, O'Connor, Conner, McMillan, & Ferguson). Furthermore, negative emotions have been associated with an increase in the tendency to binge in individuals with bulimia nervosa and binge eating disorder (Johnson & Larson, 1982; Kenardy, Arnow, & Agras, 1996; Chua, Touyz, & Hill, 2004). In 2007, Stein and colleagues (Stein, Kenardy, Wiseman, Zoler Dounchis, Arnow, & Wilfley) found that participants attributed binge episodes more frequently to their mood, rather than hunger or abstinence violation. In 2002, Macht, Roth, and Ellgring found that emotion quality (e.g., joy and sadness) can impact motivation to eat, as well as influence affective responses to eating chocolate. Experimentally-induced feelings of joy increased appetite whereas feelings of sadness decreased appetite. Chocolate tasted more pleasant when participants felt joy compared to when they felt sad. In addition to emotions regulating eating, eating may also regulate emotions (Macht, 2008). Christensen's (1993) review on the use of food to regulate negative mood revealed that there is consistent evidence for the role

of carbohydrates to provide a temporary improvement in mood. Tice and colleagues (Tice, Bratslavsky, & Baumeister, 2001) found that sad, distressed participants only ate more snack foods when they thought their moods were changeable. In other words, participants ate more unhealthy foods for the purposes of making themselves feel better. Conversely, participants ate less when they were told that eating does not make one feel better, but that it can actually extend one's current mood state.

Mood and Physical Activity. Interindividual research has also shown an association between mood and physical activity levels. Aside from the link between mood and unhealthy snacks that Jones and colleagues (2007) found, they also found that negative affect was related to a reduced likelihood of exercising. In a study of adolescents, males who were more physically fit generally reported higher positive moods (Guszkowska, 2005). In Griffin's (1993) study of undergraduates, positive affect was positively related to exercise. In women, physical activity levels are associated with both depressive symptoms and daily positive emotional style over the previous two weeks (Poole, Steptoe, Wawrzyniak, Bostock, Mitchell, & Hamer, 2011). Physical activity was inversely related to negative mood. Positive emotional style and physical activity had the strongest association, where the most active participants reported greater levels of positive mood. Positive affect has been demonstrated to be associated with self-reported physical activity levels in a cross-sectional study (Kivinemi, Voss-Humke, & Seifert, 2007). As participants' affective associations regarding activity became more positive, their level of activity increased. The results of a meta-analysis revealed that exercise in the elderly is associated with improved mood (Arent, Landers, & Etnier, 2000). Studies within this meta-analysis comparing a control to an exercise group showed that exercise is related to both increased positive affect and decreased negative

affect. Likewise, studies that examined alterations in mood pre-to-posttest showed that exercise was associated with an enhanced mood.

Stress and Food Consumption. Stress is another important factor that can influence decision-making throughout the day, and is a prominent topic within health-related research (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002). There is a vast body of evidence linking a variety of stressors to health and health-related behaviors, including eating. In fact, surveys demonstrate that many people experiencing emotional stress change their eating (Macht, 2008). On average, 30% of people experience an increase in appetite or food intake and 48% of people experience a decrease. In a survey of undergraduates, both males and females reported eating as the second most frequent behavior (after exercise) used to alleviate stress (Spillman, 1990). Of the 250 men, 117 reported consuming less food during times of stress and 133 reported consuming about their typical amounts. Of the 250 women surveyed, 92 responded as eating more food during stress and 37 reported eating less food. For males, the most commonly reported comfort food was pizza, followed by soda. Women consumed sodas most frequently, followed by candy and sweets, specifically chocolate. For both men and women, carbohydrates were the most frequently reported comfort foods. In another study, nurses with high levels of perceived job stress had greater disordered eating symptoms (King, Vidourek, & Schwiebert, 2009). Thirty-three percent of nurses reported frequently or always eating when they were stressed, and 29% reported thinking about or reaching for food during times of stress. Perceived stress is also associated with a higher fat diet in working adults (Ng & Jeffery, 2003). In 2006, Devine and colleagues (Devine, Jastran, Jabs, Wethington, Farell, & Bisogni) found that parents reported unhealthy behaviors for the purposes of reducing both stress and fatigue. To reduce these factors, parents reported many

unhealthy food choice coping strategies, including skipping meals, eating take-out, and eating fast food. These unhealthy strategies are associated with both higher fat and caloric intake (Wethington & Johnson-Askew, 2009). Torres and Nowson (2007) conducted a review of the research and concluded that when individuals cope with stressors by eating more, foods high in sugar and fat are generally chosen. They also found evidence that chronic life stress is associated with a diet high in fat and a stronger preference for sweet foods. Torres and Nowson also concluded that, based on cross-sectional studies, stress is positively associated with body weight. Information from longitudinal studies also shows this association in chronic life stress and future weight gain.

Stress and Physical Activity. Stress has also been associated with physical activity, although the findings concerning their relationship have been mixed. Some studies reveal an increase in physical activity associated with stress while others have found a decrease in levels. In a survey of university students, both men and women reported exercise as the most commonly used behavior to alleviate stress (Spillman, 1990). Increases in academic demands and stress in a sample of college students was positively correlated with exercise (Griffin et al., 1993). Conversely, in a sample of working adults, high stress was associated with less exercise (Ng & Jeffery, 2003). Likewise, higher work stress was associated with less leisure-time physical activity (Kouvonen, Kivimaki, Elovainio, Virtanen, Linna, & Vahtera, 2005). Leisure physical activity has also been demonstrated to buffer physical symptoms and anxiety that accompany minor stress in college students (Carmack, Boudreaux, Amaral-Melendez, Brantley, & de Moor, 1999). In a longitudinal study, an inverse relationship was seen with perceived stress and the amount of strenuous leisure-time exercise at a two-month follow-up (Lutz, Lochbaum, Lanning, Stinson, & Brewer, 2007). A comprehensive review

maintained that exercise has a stress-buffering effect and alleviates stress (Gerber & Puhse, 2009). In adolescents of various socio-economic backgrounds, high exercise levels were related to low perceived stress and depression (Norris, Carroll, & Cochrane, 1992). Additionally, Norris and colleagues ran an experiment with three exercise intervention groups and a control group. The intervention groups were: high intensity aerobic exercise group, moderate intensity group, and flexibility group. At the end of the ten-week training period, adolescents in the high intensity group had significantly lower perceived stress than did the other three groups. In sum, physical activity has clear implications for health and well-being.

Examination of Intraindividual Research

Almost all of the previously mentioned research was based on some form of cross-sectional data and/or retrospective self-report. Problems arise from the former in that variables are generally assessed at one point in time. There is no basis from which to examine temporal effects. Additionally, the latter aspect may be limited by recall bias (Shiffman, Stone, & Hufford, 2008). Global associations can be seen, but the assessment of more dynamic interactions between variables is lacking.

Assessment Techniques. To clarify temporal effects and examine intraindividual differences, researchers have used diary studies and a technique called ecological momentary assessment (EMA). I will first describe the daily diary methodology as much of the early investigations of intraindividual research used this technique.

Daily Diary Studies. Research utilizing daily diary studies (i.e., once-a-day) typically asks participants to complete assessments at the end of the day through use of a paper-and-pencil or electronic diary. This has been a common and efficient technique within the body of

intraindividual research. However, this methodology has some significant limitations. It is subject to recall bias typical of many cross-sectional and self-report studies. While the use of daily diaries has made contributions to the literature, it does not help disentangle temporal associations.

Additionally, participants may not complete the assessments at the proper time, but may complete some or all entries at the last minute, a phenomenon termed "parking lot compliance" (Smyth & Stone, 2003). Participants may complete paper-and-pencil diaries just before they are to be turned in. As one example, Stone and colleagues (Stone, Shiffman, Schwartz, Hufford, & Broderick, 2002) examined the issue of compliance and paper diaries. An instrumented paper diary (IPD) resembling a typical paper diary was developed with one distinct difference: unnoticeable photo cells were attached to the binder spine. Computer software allowed the researchers to record whether the diary was open or closed, allowing them to know various times when the participant could be completing the diary and times when the individual was definitely not completing it. The authors found a compliance rate of 11-19%, and there was also evidence that for about a third of the time, participants completed the diaries on days other than when they were supposed to.

It is clear that paper and pencil diaries can result in poor compliance. However, compliance rates can be improved when utilizing an electronic diary. In fact, the study mentioned above compared the paper diary group with an electronic diary group. The electronic diary had an alarm clock reminder to complete the diaries and automatically date and time stamped each entry. This group had a compliance rate of 94%.

While electronic diary studies have an advantage over paper and pencil diaries, the issue of retrospective recall still remains if they are completed once a day. However, if

electronic diaries are used to assess multiple time points throughout the day, these can be classified under Ecological Momentary Assessment (EMA). The next section reviews the literature on this methodology.

Ecological Momentary Assessment. EMA involves repeated measurements of participants' experiences and behaviors within their natural environment, as they are currently experiencing it (Shiffman et al., 2008). EMA aids in minimizing recall bias by assessing participants in the current moment, or close to it, thereby increasing ecological validity. EMA also aids in examining individual microprocesses. The study of microprocesses examines the interaction of affective, cognitive, and behavioral factors throughout a short time period, and how these factors vary over time, along with changing experiences and contextual factors (Shiffman et al.). Thus, EMA enables researchers to study the intraindividual variability component that is somewhat lacking in psychological research. Also, the longitudinal aspect of EMA aids researchers in evaluating temporal sequencing of a person's experiences (Shiffman et al.). Behaviors and experiences that precede a certain event, as well as factors that follow an event, can be observed (Shiffman et al.).

EMA is not simply one technique, but it includes multiple research methods (Shiffman et al., 2008). EMA includes using personal digital assistants (PDAs), telephones, and a specific type of electronic diary (Shiffman et al.). These methods can also be accompanied by physiological measures (Shiffman et al.). The use of such techniques has gained importance and is viewed as a means by which to advance psychological research (Shiffman, et al.; Dunton & Atienza, 2009). By permitting the examination of intraindividual variability, EMA techniques allow researchers to capture a more dynamic view of peoples'

everyday lives, which allow for insight into contextual factors and temporal processes (Smyth & Stone, 2003).

Intraindividual Research and Factors Associated with Obesity

Research consisting of the two aforementioned time-varying factors of mood and stress will now be reviewed as these topics relate to physical activity and nutrition using EMA techniques in previous research. Because of the potentially significant limitations of the validity of paper-and-pencil diary studies, I will only examine the related EMA-type electronic diary findings from this methodology. However, it is important to note that they constitute a useful intermediate step in the research.

Mood and Food Consumption. In a study examining triggers of eating, female participants were assessed hourly for two days concerning various predictors and eating (Tomiyama, Mann, & Comer, 2009). With respect to mood, participants were less likely to eat during the current hour when either in a positive or negative mood. However, both positive and negative mood were associated with an increase in the participants' likelihood of eating more in the succeeding hour. In another study examining food intake and psychosocial factors, a current depressive mood state just before dinner was negatively related to food intake (Kikuchi, Yoshiuchi, Inada, Komaki, &Yamamoto, 2010).

Mood and Physical Activity. There is a greater amount of research in the literature with respect to mood and physical activity, but findings are mixed. There is a general trend concerning an associated increase in positive affect following physical activity, inconsistencies regarding negative affect, context-dependent findings, and questions concerning the timing of various events. Research will now be presented as it relates to these issues.

In an EMA study examining children ages 9-13 during nonschool hours, the relation between mood and physical activity varied depending on different contextual factors (Dunton, Liao, Intille, Wolch, & Pentz, 2011). Lower positive affect scores and enjoyment were reported when children were active at someone else's house compared with activity episodes that took place outdoors or in their own yards. Scores were also higher when children were outside as opposed to being inside at home. Also, children reported greater negative affect when they were physically active alone and with only family compared to being active with only friends. However, in an additional study examining factors associated with physical activity levels in children, there was no significant relation between mood and activity (Liao, Intille, Pentz, & Dunton, 2010).

Schwerdtfeger and colleagues (Schwerdtfeger, Eberhardt, Chmitorz, & Schaller, 2010) examined whether momentary affect could predict bodily movement in a sample of healthy volunteers (ages 18-73). The latter component was assessed by wearing of an Actigraph, while mood states were assessed hourly for one day and at the end of the day by responding on a PDA. Increases in both positive and negative affect preceded increases in bodily movement. In regards to the former finding, when participants were feeling happy, lively, etc., they were more likely to engage in moderate and vigorous activity within the next 30 minutes. The onset of bodily movement that followed negative affect might have been an attempt to improve mood. In an additional study, participants wore accelerometers and reported on mood every hour via handheld computers for one day. Results revealed alterations in positive affect following bodily movement, but there was no significant relationship with negative affect (Schwerdtfeger, Eberhardt, & Chmitorz, 2008).

Stress and Food Consumption. Henker and colleagues (Henker, Whalen, Jamner, & Delfino, 2002) examined daily experiences in adolescents with differing anxiety levels. The adolescents reported on various feelings and activities on electronic diaries every 30 minutes for two 4-day intervals. Results revealed that adolescents who reported greater levels of anxiety and stress also had stronger urges to eat.

Current Study

Need For EMA Research. One can see that EMA techniques are being utilized in the areas of mood and stress in regards to eating and physical activity. However, there is not an extensive amount of research on these topics. There are mixed findings within the few studies in this body of literature. Furthermore, there are methodologically weak aspects which need to be addressed. While the concept of mood seems to be much more prominent in the literature compared to stress, research is still lacking or needs to be re-examined. I am unaware of any previous research examining stress and physical activity from a momentary perspective and have come across only one study in regards to stress and eating. Temporal effects need to be better addressed, such as whether differing aspects of these variables predict healthy eating and physical activity; are consequences of such behaviors; or play a role in both temporal aspects. There is minimal research on these effects, along with inconsistent findings.

Purpose. The purpose of the current study was to examine how various time-varying factors are related to daily processes of decision-making regarding eating and physical activity. Temporal associations were examined using an EMA approach to help better establish those factors that may precede and follow healthful eating and physical activity, or those that are related to not engaging in these behaviors. Research has demonstrated some

temporal effects between factors, such as mood and stress, but the present study examined which aspects are most important throughout the day, and investigated potential differences in factors that influence eating versus activity decisions. This study also extends others in that participants' responses were time-stamped through the use of a mobile device. The participant's own mobile device (e.g., smartphone) was used in hopes of enhancing compliance due to its user-friendly and minimally intrusive aspects (Smyth & Stone, 2003). The accurate timing along with moment-to-moment variations helped to establish a more comprehensive look at the contexts in which one individual makes certain health decisions regarding physical activity and eating.

Hypotheses. Seven specific hypotheses were assessed in this study:

Hypothesis 1: a) Positive mood will precede healthful eating.

b) Positive mood will precede physical activity.

Hypothesis 2: a) Positive mood will follow healthful eating.

b) Positive mood will follow physical activity.

Hypothesis 3: a) Stress will be negatively associated with the likelihood of engaging in healthful eating.

b) Stress will be negatively associated with the likelihood of engaging in physical activity.

Hypothesis 4: a) Physical activity will be associated with a reduction in stress.

Method

Research Design

The present study was an EMA study that incorporated a cell phone web application to examine how mood, stressors/stress, and socio-contextual factors related to eating and

physical activity. Specifically, the effects of mood and stress were examined in the current study. This design minimized recall bias and maximized ecological validity.

Participants

Participants were undergraduate psychology students from Virginia Commonwealth University at least 18 years of age. The study was conducted in two parts and participants were recruited through an online research participation management system called SONA for Part 1. Participants in Part 2 were required to speak English and have a smartphone with texting and Internet capabilities. Individuals with eating disorder symptoms, various eating and physical activity restrictions, depression symptoms, and who were ever diagnosed with bipolar disorder or schizophrenia were excluded from Part 2. Two hundred forty-seven students participated in Part 1 of the study and 26 students participated in Part 2 of the study.

Procedure

The current study was conducted in two parts. Part 1 was an online survey worth .5 course credit for which 247 individuals participated. Participants were required to fill out surveys on demographics, mental health, and cell phone questions. At the end of the study, Part 2 was briefly described and anyone who wished to participate could leave his or her contact information. Eligible students (up to 15 of each gender), chosen at random, were invited to attend an information session. Individuals were excluded if they had either a bipolar or schizophrenia diagnosis; had various eating and physical activity restrictions; if they scored 11 or higher on the Center for Epidemiological Studies-Depression Scale (CES-D) Short Form; if they did not meet certain cell phone requirements (i.e., have an iPhone or Android, have texting and Internet capabilities); and if they showed symptoms of eating disorders, which were based loosely on DSM criteria. For example, if individuals answered

that they had ever had a period of time where they weighed much less than what other people thought they should weigh *and* that they were at least moderately afraid that they might gain weight or become fat, and/or they felt fat during this time, they were excluded. Additionally, individuals were excluded if they had ever had eating binges where they felt that their eating was very much out of control and/or if they had more than one binge episode in a month. Finally, if individuals responded that, during their most extreme efforts to control their shape and weight, they engaged in unhealthy behaviors (e.g., vomiting, using laxatives, fasting, etc.) at least once a week, they were also excluded.

Eligible and willing participants came in person to the psychology department where they were given a more detailed description of the study. The duration of the study for each participant lasted for a total of six days (a Thursday through a Tuesday) and six measurements, taken approximately every two and a half hours, were administered daily. The assessments began at approximately 9:30am and ended around 10:00pm. Participants needed to have access to a cell phone as they were texted with a website link, which was the link they accessed throughout the study when prompted. Participants completed an informed consent form and were walked through each of the questions and responses in the EMA questionnaire. They each submitted a mock submission in order to ensure their understanding of the procedure. Any questions or concerns were addressed. Participants had the option of leaving if they did not wish to participate. At the end of the study, they were compensated 3 course credits and up to $50.00 (dependent upon the number of assessments they completed) for their time and effort. 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 X $50 = $40).

Measures

The SONA questionnaire for Part 1 of the study was divided into four sections. These sections included: demographics; an eating disorder screening questionnaire; depression scale; and cell phone questions. See Appendix A for the SONA questionnaire.

Demographics. Participants were asked to report on demographic information. This information addressed: gender; ethnicity; age; year in school; GPA; dieting history within one's lifetime, within the last year, and current dieting status; weight; height; SES; and schizophrenia or bipolar diagnosis. This section also addressed whether the participant had any illness or disability that required him or her to eat or exercise in a particular manner, so that these circumstances could be controlled for.

Eating Disorder Screening Questions. Participants were also required to fill out a questionnaire for eating disorder symptoms adapted from items used in the Mid-Atlantic Twin Registry (American Psychiatric Association, 2000, *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., text revision; Bulik, Sullivan, Wade, & Kendler, 2002). Individuals with eating disorders may not be representative of the general population due to known substantial differences, such that they may engage in unhealthy behaviors of binging and vomiting when in a negative mood or if they perceive their stressors as highly severe (Hilbert, Rief, Tuschen-Caffier, de Zwaan, & Czaja, 2009; Hilbert & Tuschen-Caffier, 2007). Therefore, participants with such symptoms were excluded.

Center for Epidemiological Studies-Depression Scale (CES-D) Short Form. Participants were also asked to report on symptoms of depression on a scale from *Rarely or*

none of the time (less than 1 day) to *Most or all of the time (5-7 days)*. The CES-D is a depression-screening tool used in the general population (Radloff, 1977). This particular short form was developed in 2004 by Cole, Smith, Rabin, and Kaufman. A sample question includes, "During the past week, I felt my life had been a failure." This measure showed adequate internal consistency ($\alpha = .76$).

Cell Phone Questions. Participants were also required to answer questions concerning whether they owned a particular type of cell phone as well as texting and internet capabilities. These questions were used to screen for potential participants for Part 2 of the study. If the participant did not own an iPhone or an Android cell phone or did not have texting and internet capabilities, they were excluded from Part 2.

EMA Questionnaire. The EMA questionnaire consisted of five sections. The questionnaire was designed to be short to reduce participant burden. See Appendix B for the EMA Questionnaire.

The first section dealt with mood and had six items from the Positive and Negative Affect Scale (PANAS) (Watson, Clark, & Tellegen, 1988). Three words were used to assess positive affect: enthusiastic, excited, and inspired. Three words were also used to assess negative affect: upset, scared, and nervous. These items were chosen due to their high factor loadings in the short form version of the PANAS (Mackinnon, Jorm, Christensen, Korten, Jacomb, & Rodgers, 1999). Participants rated their current mood on a scale from 1 (very slightly or not at all) to 5 (extremely). Both positive and negative affect provided adequate internal consistencies, respectively ($\alpha = .88$) and ($\alpha = .76$).

The second section addressed current stress level, "Please indicate how stressed you are feeling on a scale from 0-10 (no stress to extremely high stress)." Previous literature has

utilized this type of momentary assessment of stress level (Clark, Warren, Hagen, Johnson, Jenkins, Werneburg, & Olsen, 2011).

The third section addressed foods eaten within the last two and a half hours. Participants had to answer whether they had eaten or not. They also had to give a detailed list of foods that were eaten as well as the amount. Past literature has employed this type of open-ended response with regards to food consumption (Jones et al., 2007; O'Connor, Jones, Conner, McMillan, & Ferguson, 2008). Attempts were made to classify foods as either healthy, unhealthy, or mixed/ambiguous. Categorizing specific types of foods as being more healthful or not has been used in previous literature (Boutelle et al., 2002). Food consumption that was entirely healthy was categorized as "healthy;" food consumption that was entirely unhealthy was categorized as "unhealthy;" and food consumption that had both healthy or unhealthy foods, or was ambiguous (e.g., cereal) was categorized as "mixed/ambiguous." Some examples of healthy food include: fruits, vegetables, and whole-grain foods. Examples of unhealthy food include: desserts, fast food, and junk food. Participants also had to address their primary reason for eating from a list of options. The motivations listed have been adopted from two scales that assess motivations for eating: Motivations to Eat (Jackson, Cooper, Mintz, & Albino, 2003) and the Motivations for Eating Scale (Hawks, Merrill, Gast, & Hawks, 2004). In addition to these eating questions, participants had to address their location and who they were with at the time that they ate. Previous literature has demonstrated that where a person is located can have an impact on the kind and amount of food a person eats (Binkley et al., 2000; Patel & Schlundt, 2001). Who a participant is with has also been associated with the amount of food a person eats (Patel & Schlundt, 2001).

The fourth section addressed physical activity and asked if the participant had been physically active within the last two and a half hours. If they answered yes, participants were instructed to list the specific activities, the amount of time spent in each one, and whether the activities were of mild, moderate, or strenuous intensities. During the orientation meeting, participants were given brief definitions of the various intensities (e.g., minimal effort, heart beats rapidly) and examples of each intensity similar to those given by Ng and Jeffery (2003), such as running, soccer, and football for strenuous activity. Having participants self-report on physical activity has been widely used in past literature (Giacobbi, Hausenblas, & Frye, 2005; Stetson, Dubbert, Rahn, Wilner, & Mercury, 1997; Wichers, Peeters, Rutten, Derom, Delespaul, Jacobs, Thiery, & van Os, 2011; Ng & Jeffery, 2003; Lutz, Lochbaum, Lanning, Stinson, & Brewer, 2007). Participants also had to address their location and who they were with at the time that they exercised. Previous literature has demonstrated that where a person is located can have an impact on physical activity levels (Dunton et al., 2011). Who a person is with has also been associated with whether someone engages in physical activity or not, as well as the relationship between mood and physical activity (Dunton et al., 2011; Dunton, Atienza, Castro, & King, 2009).

The fifth section asked if something stressful had happened within the last two and a half hours. If the participant answered yes, he or she was prompted to list the event(s) and indicate how stressful the event(s) was/were on a scale from 0 to 10 (no stress to extremely high stress). Previous literature has utilized self-perceived ratings of stressors and intensity (Kanner, Coyne, Schaefer, & Lazarus, 1981; O'Connor et al., 2008).

Data Analysis

All data from Part 1 were analyzed (e.g., examining exclusionary criteria) using SPSS 20. Clean-up and reorganization of the Part 2 data was also conducted in SPSS. In Part 2, multiple observations from each participant were collected over time and these observations, or occasions, were nested within each person. Therefore, given the hierarchical structure of the data and both the binary and continuous forms of the respective outcome variables, data were analyzed using a hierarchical generalized linear model (HGLM) approach for binary outcomes and a hierarchical linear model (HLM) approach for continuous outcomes in Hierarchical Linear and Nonlinear Modeling (HLM) 7 Student Version. Intraindividual variability was assessed by analyzing time-varying covariates, such as stress and mood.

I will first describe the analysis as it pertains to the binary outcome variables. These outcome variables were whether or not someone engaged in physical activity and healthy eating. The physical activity variable was coded as a yes/no response. The eating variable was coded as either "healthy" if the participant had eaten healthy foods or "not healthy" if the participant had not eaten any food or had eaten but not healthy foods (i.e., unhealthy or mixed/ambiguous). Thus, these were both binary variables and the analysis was conducted using an HGLM approach.

All data were analyzed at level one. Level one modeled change over time, or the repeated measures for each participant. This level examined within-individual variability. The time-varying factors of stress and mood, as well as the outcome variables were analyzed at level one. Change in the outcome variables was examined as a function of time for each individual. An HGLM equation has a similar form to the following equation:

$$\text{Logit}(P_{ti}) = \eta_{ti} = \beta_{00} + \beta_{01}X_{it} + r_{0i}$$

where $_t$ represents each occasion nested within each individual $_i$ over time $_t$, β_{00} is the within-person intercept that varies randomly across individuals, X_{it} is a level one predictor (e.g., stress) having a fixed effect β_{01}, r_{0i} is a person-specific random error normally distributed with mean 0 and variance tau, and P_{ti} is the probability of obtaining the desired binary response outcome for occasion $_t$ nested within individual $_i$. Eta (η) is a symbol for the linearized predictor and is related to random error that changes across people. Using the theory of generalized linear models, a logit link function was used to model the binary outcome with a linear combination of predictor variables.

Due to the dichotomous outcomes, hypotheses 1a, 1b, 3a, and 3b were analyzed using HGLM.

To test hypothesis 1a: Positive mood will precede healthful eating, the within-person level of positive mood was entered into a regression equation to assess the probability that an individual engages in healthful eating ($P_{it} = P(Y_{it} = 1)$).

To test hypothesis 1b: Positive mood will precede physical activity, the within-person level of positive mood was entered into a regression equation to assess the probability that an individual engages in physical activity ($P_{it} = P(Y_{it} = 1)$).

To test hypothesis 3a: Stress will be negatively associated with the likelihood of engaging in healthful eating, the within-person level of stress was entered into a regression equation to assess the probability that an individual engages in healthful eating ($P_{it} = P(Y_{it} = 1)$).

Finally, to test hypothesis 3b: Stress will be negatively associated with the likelihood of engaging in physical activity, the within-person level of stress was entered into a

regression equation to assess the probability that an individual engages in physical activity ($P_{it} = P(Y_{it} = 1)$).

In order to analyze the continuous outcomes, an HLM was used that is very similar to an HGLM approach. An HLM equation has a similar form to the following equation:

$$Y_{it} = \beta_{00} + \beta_{10}X_{it} + r_{0i} + e_{it}$$

Where β_{00} is the intercept indicating the mean outcome when $X_{it} = 0$, β_{10} is the effect of the covariate, r_{0i} is a person-specific random error that is normally distributed with mean 0 and variance tau, and e_{it} is an occasion-specific random error that is normally distributed with mean expectation 0 and variance σ^2 for r_{0i} and e_{it} independently. The level 1 predictor, X_{it}, was represented by either a 0 or 1, corresponding to whether or not an individual engaged in physical activity or healthy eating.

To test hypothesis 2a: Positive mood will follow healthful eating, the within-person level of positive mood was used as a continuous outcome variable. Healthful eating episodes (X=1) were compared with non-eating or unhealthful eating episodes (X=0) on mood.

To test hypothesis 2b: Positive mood will follow physical activity, the within-person level of positive mood was again used as the continuous outcome variable. Physical activity episodes (X=1) were compared with physically inactive episodes (X=0) on mood.

To test hypothesis 4a: Physical activity will be associated with a reduction in stress, the within-person level of stress was used as a continuous outcome variable. For this hypothesis, a difference score had to be created to illustrate a reduction in stress. The physical activity that took place between time one (T1) and time two (T2) was regressed on the change in stress between T2 and T1. Physical activity episodes (X=1) were compared with physically inactive episodes (X=0) on mood.

Finally, to capture a more complete picture, the hypotheses were also examined from a different time perspective. Instead of only looking at the effect of time one (T1) on time two (T2) (a 2.5 hour interval), the effect of time one (T1) on time three (T3) (a five hour interval) was also examined. These additional analyses were conducted in order to assess the potential that a predictor might have a delayed effect on an outcome.

Results

Descriptive Results

Part 1. Two-hundred and forty-seven individuals participated in Part 1 of the study. Participants ranged in age from 17 to 57 years ($M = 20.77$, $SD = 4.165$) and the majority of the sample was female (64.4%). Most of the participants were White (46.6%), followed by African-American (20.2%), Asian-American (16.6%), Hispanic/Latino (6.5%), and Native-American (.4%). Seventy percent of the participants were iPhone or Android users (iPhone $n = 95$; Android $n = 78$). Out of the 247 participants, 138 left a form of contact information (e.g., email, phone number) indicating interest in Part 2 of the study. As previously stated, some individuals were excluded due to meeting at least one of the various exclusionary criterion. See Table 1. Out of the 138 individuals who were interested in Part 2, only 42 (30.4%) were eligible.

Table 1.

Number of Participants Excluded From Part 2

Exclusionary Criterion*	***n***	**%**
Cell Phone Type	43	31.1
Texting	1	0.7
Cell Phone Internet	15	10.9
Depression Score	45	32.6

Exclusionary Criterion*	*n*	%
Schizophrenia	0	0
Bipolar	0	0
Eating Restrictions	9	6.6
Physical Activity Restrictions	9	6.6
ED Fear of Fat Characteristics	10	6.6
ED Binging Characteristics	31	22.5
ED Vomiting	10	7.4
ED Laxatives	4	2.9
ED Diuretics	3	2.2
ED Diet Pills	13	9.6
ED Fast	12	8.8
ED Excessive Exercise	7	5.1

N = 138
* Criteria overlap among participants.
Note. ED = Eating Disorder

Part 2. Participants in Part 2 of the study ranged in age from 18 to 33 years (*M* = 21.31, *SD* = 4.20). The sample consisted of 15 females and 11 males (*N* = 26). The majority of the sample was White (46.2%), followed by African-American (26.9%), Asian-American (19.2%), and Hispanic/Latino (7.7%). Participants' body mass index ranged from 18.24 to 29.69 (*M* = 24.25, *SD* = 2.69).

There were 788 usable EMA assessments out of a total of 936 indicating a high response rate of 84.2%. Twenty-eight assessments were excluded due to timing issues, such as the participant answering a text message back to back (e.g., 8:05pm and 8:10pm) or the participant answering the last assessment of the night the following morning (e.g., 1:00am). There was a total of 382 eating events. The categorization of food categories was as follows: 11.7% healthy, 20.3% mixed/ambiguous, and 16.5% unhealthy; individuals reported not eating 51.5% of the time. There was a total of 197 physical activity events. The categorization of intensities was as follows: 17.0% mild, 4.4% moderate, and 1.6% vigorous;

individuals reported not being physically active 76.9% of the time. Across participants, the mean current positive mood was 5.63 (*SD* = 2.794); the mean current negative mood was 3.69 (*SD* = 1.539); and the mean current stress level was 2.24 (*SD* = 2.386).

Hypotheses 1a, 1b, 3a, and 3b were analyzed using HGLM due to their dichotomous outcomes. See Table 2 for coefficients, standard errors, and *p*-values for each hypothesis. Hypothesis 1a: The logit of the probability of engaging in healthful eating was not linearly associated with positive mood (β_{10} = - 0.02, p = .721). Therefore, there was no evidence to support the hypothesis that positive mood will precede healthful eating. The model fitted for testing this hypothesis is:

$$\text{Prob}(HEALTHYFOOD_{ti}=1) = P_{ti}$$

$$\log[P_{ti}/(1 - P_{ti})] = \eta_{ti} = \beta_{00} + \beta_{10}*POSITIVEMOOD_{ti} + r_{0i}$$

Hypothesis 1b: The logit of the probability of engaging in physical activity was also not linearly associated with positive mood (β_{10} = .05 p = .317). Therefore, there was no evidence to support the hypothesis that positive mood will precede physical activity. The model fitted for testing this hypothesis is identical to the one for the previous hypothesis except for a different outcome:

$$\text{Prob}(PHYSICALACTIVITY_{ti}=1) = P_{ti}$$

$$\log[P_{ti}/(1 - P_{ti})] = \eta_{ti} = \beta_{00} + \beta_{10}*POSITIVEMOOD_{ti} + r_{0i}$$

Hypothesis 3a: The logit of the probability of engaging in healthful eating was not linearly associated with stress (β_{10} = - 0.02, p = .809). Thus, the hypothesis that stress will be negatively associated with the likelihood of engaging in healthful eating was not supported. The model fitted is:

$$\text{Prob}(HEALTHYFOOD_{ti}=1) = P_{ti}$$

$$\log[P_{ti}/(1 - P_{ti})] = \eta_{ti} = \beta_{00} + \beta_{10}*STRESS_{ti} + r_{0i}$$

Hypothesis 3b: The logit of the probability of engaging in physical activity was also not linearly associated with stress ($\beta_{10} = -0.05$, $p = .425$). Thus, the hypothesis that stress will be negatively associated with the likelihood of engaging in physical activity was not supported. The model for this hypothesis is:

$$\text{Prob}(PHYSICALACTIVITY_{ti}=1) = P_{ti}$$

$$\log[P_{ti}/(1 - P_{ti})] = \eta_{ti} = \beta_{00} + \beta_{10}*STRESS_{ti} + r_{0i}$$

Hypotheses 2a, 2b, and 4a were analyzed using an HLM approach due to their continuous outcomes. Hypothesis 2a: There was also no temporal linear association of positive mood following healthful eating ($\beta_{10} = 0.24$, $p = .383$). Thus, there was no evidence to support the hypothesis that positive mood will follow healthful eating. The model fitted for this hypothesis is:

$$POSITIVEMOOD_{ti} = \beta_{00} + \beta_{10}*HEALTHYFOOD_{ti} + r_{0i} + e_{ti}$$

Hypothesis 2b: However, there was a temporal linear association of positive mood following physical activity ($\beta_{10} = 0.77$, $p < 0.001$). Thus, there was evidence to support the hypothesis that positive mood will follow physical activity, indicating a .77 unit increase in positive mood for every unit increase in physical activity. The model fitted to test this hypothesis is:

$$POSITIVEMOOD_{ti} = \beta_{00} + \beta_{10}*PHYSICALACTIVITY_{ti} + r_{0i} + e_{ti}$$

Hypothesis 4a: Physical activity was not linearly associated with a reduction in stress ($\beta_{10} = -0.11$, $p = .549$). Therefore, the hypothesis that physical activity will be associated with a reduction in stress was not supported. The fitted model for this hypothesis is:

$$CHANGESTRESS_{ti} = \beta_{00} + \beta_{10}*PHYSICALACTIVITY_{ti} + r_{0i} + e_{ti}$$

Table 2.

Hypotheses Results

Hypothesis	**Coefficient**	**Standard Error**	***p*-value**
1A	-0.02	0.069	0.721
1B	0.05	0.055	0.317
2A	0.24	0.272	0.383
2B	0.77	0.219	0.001*
3A	-0.02	0.078	0.809
3B	-0.05	0.067	0.425
4A	-0.11	0.176	0.549

*$p < 0.001$

Finally, when examining the relation of the variables from T1 on T3, all of the hypothesis tests resulted in the same inferences, except for one hypothesis. Hypothesis 1b: Positive mood will precede physical activity became significant. The coefficient was 0.19, the standard error was 0.090, and the *p*-value was 0.035. It is interesting that this relationship was significant roughly five hours apart unlike the results of two and a half hours apart. It seems that being in a positive mood can lead one to engage in physical activity, but that it may take longer (i.e., five hours) for this temporal association to play out.

Discussion

The primary aim of this study was to examine temporal associations of the time-varying factors of stress and mood on eating and physical activity using an EMA approach. Although only one hypothesis was supported, most results were consistent with some aspect of the previous literature. One goal of this study was to investigate temporal associations and the mixed findings within the literature, and the nonsignificance of many of the results helps to support one side over another through more rigorous evaluation.

The hypothesis that "positive mood will precede healthful eating" was not supported by the data. Cross-sectional studies have found a relation between positive affect and eating more healthy foods (Griffin et al., 1993; Fedorikhin & Patrick, 2010), but no temporal associations. Furthermore, one study that experimentally induced feelings of joy and sadness into participants found that feelings of joy increased appetite, but that chocolate tasted more pleasant (Macht et al., 2002). Thus, it could be that positive mood may lead one to actually engage in more unhealthy eating because this type of food tastes better. Overall, however, more cross-sectional studies have found consistent findings with negative mood and eating behavior, therefore it may be that negative affect plays a much stronger role when it comes to eating over positive affect (Jones et al., 2007; Stein et al., 2007).

The hypothesis that "positive mood will precede physical activity" was also not supported. Cross-sectional research has shown a relation between positive affect and physical activity, but again, no temporal associations have been established (Guszkowska, 2005; Griffin et al., 1993; Kivinemi et al., 2007; Arent et al., 2000). It could be that positive affect actually follows physical activity, and in fact, the current study supports this relationship as that particular hypothesis was significant. In the two previously reviewed EMA studies, Liao and colleagues (2010) found no link between mood and activity in children, which supports the current hypothesis, but Schwerdtfeger and colleagues (2010) found that increases in both positive and negative mood predicted increases in bodily movement. However, they followed participants for only one day which may not have allowed for a more comprehensive picture of the relationships.

Interestingly, when this hypothesis was examined from the perspective of T1 on T3, the relation was significant. Positive mood did precede physical activity but this event took

place roughly about five hours after the current positive mood as opposed to two and a half hours later. However, this result may be related to an opportunity factor such that participants may not have been able to exercise when they wanted (e.g., in class or work) but had to wait until they had time to exercise.

The hypothesis that "positive mood will follow healthful eating" was not supported. As previously mentioned, there is more literature on the association between negative mood and eating (Jones et al., 2007; Stein et al., 2007), which implies that negative mood may have a stronger role in eating behaviors. Furthermore, a review by Christensen (1993) found that there is consistent evidence for the role of carbohydrates to provide a temporary improvement in mood. Tice and colleagues (2001) found that participants ate more unhealthy foods for the purposes of making themselves feel better. Therefore, it may actually be that individuals have more positive moods after unhealthy eating. Individuals may simply have a neutral mood after healthy eating, or it could be that eating healthy foods is somewhat unpleasant for some people (i.e., they are dieting, do not enjoy the taste of many healthy foods).

The hypothesis "positive mood will follow physical activity" was supported by the data. The general relation between positive mood and physical activity is consistent with cross-sectional research (Guszkowska, 2005; Griffin et al., 1993; Kivinemi et al., 2007; Arent et al., 2000). This temporal relationship is also consistent with results from a meta-analysis of correlational and experimental studies examining the effects of exercise on mood in older adults (Arent et al., 2000). Studies comparing a control to an exercise group showed that exercise is related to both increased positive affect and decreased negative affect. Exercise was also associated with an enhanced mood in studies that examined alterations in

mood pre-to-posttest. This finding is also consistent with the EMA study conducted by Schwerdtfeger and colleagues (2008) in that alterations in positive affect were seen following bodily movement. The current study provides a more rigorous evaluation of this relationship as participants in the former study were followed for only one day.

The hypothesis "stress will be negatively associated with the likelihood of engaging in healthful eating" was not supported. The fact that this hypothesis was not supported, is consistent with some of the previous literature. In 2008, Macht found that 48% of individuals decrease their eating when they are stressed. It could be that stress in the current sample was not necessarily inversely related to healthy eating in particular, but that stress decreased their likelihood of eating in general. Also, individuals in another study reported eating as the second most frequent behavior to alleviate stress, after exercise (Spillman, 1990). Consistent with this finding, it might be that participants in the current study were more likely to eat in response to feelings of stress, which may include both healthy and unhealthy eating. Furthermore, in the EMA study by Henker and colleagues (2002) that examined stress and eating, participants who reported greater levels of stress also reported stronger urges to eat, which supports the idea that participants in the current study may have eaten in response to stress. Finally, it could be that due to the relatively low stress experienced in this sample, no relationship between stress and healthy eating could be established.

The hypothesis "stress will be negatively associated with the likelihood of engaging in physical activity" was also not supported in this study. As was postulated with the last hypothesis, due to the sample's generally low stress level, it may have been difficult to establish any relationship between stress and physical activity. However, due to the mixed literature in this area, the current null finding is consistent with some previous literature.

Spillman (1990) and Griffin and colleagues (1993) both found that university students used physical activity as a way of coping with stress. Interestingly, however, high stress levels have been associated with low exercise in two samples of working adults (Ng & Jeffery, 2003; Kouvonen et al., 2005). This association may be due to higher stress levels in working adults or less time to exercise. If the current study had been conducted in a sample of working adults, this particular hypothesis might have been supported.

Finally, the hypothesis that "physical activity will be associated with a reduction in stress" was also not supported. Once again, a low average stress level in the sample may have played a role. Because stress levels tended to be low in the students, it makes sense that examining a reduction in stress would not be related to physical activity. However, the current study is the first one to my knowledge that has examined both physical activity and stress from an EMA perspective.

Limitations and Strengths

Limitations of this study should be considered when interpreting the findings. First, the sample size was relatively small and participants were recruited from psychology courses from only one university. Despite the benefits of EMA methodology, assessments were still based upon self-reports and may have been inaccurate. Additionally, some participants answered text messages back to back or waited too long to answer the last text message of the day, and therefore some responses (3.5%) had to be excluded.

Furthermore, the food categorization by the author was also subjective. Placing participants' food into categories of healthy, unhealthy, and mixed/ambiguous was a limitation of the study. For example, categorization was not based upon total daily food consumption. It could be that something high in fat or calories may still be considered

healthy if it is contributing to an overall healthy diet. As one instance, a spoonful of peanut butter may be high in fat, but simultaneously provides a decent amount of protein. Assessing food consumption in its entirety may have been beneficial.

There were also multiple waves of participants that were assessed at different times. Specifically, data collection began in the Spring and continued through the end of Summer. Responses may have differed among participants due to varying school workloads (e.g., full time versus one class), vacations taken during the summer, change in weather, availability of various foods, and opportunities for physical activity. However, considerations were made to keep some consistency in regards to assessment times. For example, none of the participants were assessed during finals week.

The study was also limited to iPhone and Android smartphone users due to the particular web application employed. Furthermore, participants had to have both Internet and text messaging services. These technology restrictions also excluded some interested participants, but it is important to note that roughly 70% of the participants were eligible based on these technology considerations.

Excluding participants due to other exclusionary criteria was also a limitation of the study. After examining these criteria, many interested participants were ineligible. Although having exclusion criteria was intended to serve as a form of control (i.e., to avoid recruiting individuals with eating disorder symptoms, depression symptoms, etc.), this also doubled as a limitation in that many individuals could not participate.

Despite the limitations of this study, it also had numerous strengths. This is one of the first studies to examine both eating and physical activity behaviors simultaneously from a momentary perspective. This is also the first study that I am aware of to examine stress and

physical activity using EMA and one of the first regarding stress and eating. Many previously examined cross-sectional relationships were more rigorously evaluated in the current study.

Using EMA addressed some methodologically weak aspects of previous research. Participants were assessed multiple times a day and responses were both time- and date-stamped. These assessments were roughly two and a half hours apart so as to minimize the potential of inaccuracies of retrospective reporting. Furthermore, the questions which participants were asked to remember (e.g., engaging in physical activity, eating) should be salient events for a person to recall. Additionally, questions were also asked concerning the present moment (e.g., stress level, mood) which would be highly salient to the person. Participants were also allowed to use their own cell phones, which may have enhanced compliance due to user-friendliness and minimal intrusion (Smyth & Stone, 2003).

Future research should assess a more generalizable sample, such as a wider variety of college students and their non-college peers. It would also be beneficial to assess working adults, especially when examining stress and physical activity. It may also be worthwhile to include participants who have any type of cell phone with texting and Internet service, or to give participants cell phones with the necessary technology already built in. Future research should also examine the association of negative affect on eating and activity events as well as the relationship between variables and unhealthy eating as opposed to just healthy eating. Future studies should also incorporate more objective ratings for both physical activity and eating behaviors, such as using accelerometers and/or having participants take pictures of their food. For example, Kikuchi and colleagues (2010) used a PDA-based food diary with food photos and found that depressive mood just before dinner was negatively correlated

with energy intake. When examining motivational factors and mood in the context of physical activity, Liao and colleagues (2010) had children wear an accelerometer and compared survey responses to time-matched steps and minutes of physical activity episodes of moderate-to-vigorous intensities.

When examining food consumption, future studies might also examine total daily intake, various food groups, or specific servings of various healthy (e.g., fruits and vegetables) and unhealthy (e.g., cakes, cookies) foods. For example, Patel and Schlundt (2001) had obese participants record the food they ate, the amount, and code the foods into food groups. This food coding was then entered into a computer program to create nutrient information for each entry, and totals such as mean total energy and percent calories from fat were computed. Participants should also be assessed during one general time point. For example, it would be beneficial to assess participants during the same part of the semester.

Conclusion

In conclusion, the present study used an EMA approach to examine the relationships of stress, mood, physical activity, and healthy eating in a sample of undergrads. Positive mood was found to follow physical activity episodes up until five hours later. Positive mood was also found to precede physical activity up until five hours before the event took place. Furthermore, due to the mixed findings in the literature concerning mood, stress, eating, and physical activity, many of the non-significant findings actually provided support for one side of the literature over another from a more rigorous viewpoint. This study was also the first (that I am aware of) to examine stress and physical activity from a momentary perspective and is one of the first in regards to stress and eating.

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Appendix A

SONA Questionnaire (Part 1)

Please answer the following questions:

1. Are you a male or female? MALE FEMALE

2. What is your ethnicity?

   White African-American Hispanic/Latino Asian-American Native American

   Other _____

3. How old are you? _____

4. What is your year in school? _____

5. What is your GPA? _____

6. Have you ever dieted in your lifetime? YES NO

7. If so, have you dieted in the last year? YES NO

8. Are you currently dieting? YES NO

9. How much do you weigh? If uncertain, please give your best estimate. _____ lbs.

10. How tall are you? _____

11. What is your parent's combined annual income?

   Below $15,000 $15,000-29,000 $30,000-44,000 $45,000-59,000
   $60,000 and above

12. What is your annual income?

   Below $15,000 $15,000-29,000 $30,000-44,000 $45,000-59,000
   $60,000 and above

13. Do you currently have any illness or disability that requires you to eat in a certain way?

   YES NO

If yes, please explain.

14. Do you currently have any illness or disability that requires you to exercise or be physically active in a certain way?

YES NO

If yes, please explain.

15. Have you ever been diagnosed with schizophrenia?

YES NO

16. Have you ever been diagnosed with bipolar disorder?

YES NO

1. Have you ever had a period of time when you weighed much less than what other people thought you *should* weigh?

YES NO

If Yes, proceed to question #1a

If No, skip to question #2

1a. If you checked Yes:

a. How old were you *when you weighed much less*? _____years

b. How low did your weight get *when you weighed much less*? _____pounds

c. How tall were you *when you weighed much less*? _____feet _____inches

1b. During the time when you were at this low weight, how afraid were you that you might gain weight or become fat?

Extremely afraid

Very afraid

Moderately afraid

Slightly afraid

Not afraid

1c. During the time when you were at this low weight, did you feel fat?

Extremely

Very much

Moderately

Slightly

Not at all

2. Have you *ever* had eating binges when you ate what most people would regard as an unusually large amount of food in a short period of time?

YES NO

If No, skip to question #3

2a. When you were having eating binges, did you feel that your eating was out of control?

Extremely

Very much

Somewhat

Not at all

2b. When you were bingeing the most, how many binges would you have in a month?

_____

3. Which of the following have you ever done or used to control weight? (Circle all that apply).

Made yourself vomit

Laxatives

Diuretics (water pills)

Diet pills (over the counter or prescription)

Fasted or not eaten (for 24 hours or more)

Exercised excessively

Other methods _____

None of these

3a. If you circled any of the above EXCEPT "None of these," please fill out this table.

During your most extreme efforts to control your shape and weight how often do you or did you do the following:	**Every day**	**Nearly every day**	**A few days a week**	**Once a week**	**Less than once a week**	**I've done it once**
Make yourself vomit	1	2	3	4	5	6
Laxatives	1	2	3	4	5	6
Diuretics (water pills)	1	2	3	4	5	6
Diet pills (over the counter or prescription)	1	2	3	4	5	6
Fast or not eat (for 24 hours or more)	1	2	3	4	5	6
Exercise more than 2 hours per day	1	2	3	4	5	6
Other methods- please indicate: _____	1	2	3	4	5	6

Below is a list of ways you might have felt or behaved. Please indicate how often you have felt this way during the past week.	**Rarely or none of the time (less than 1 day)**	**Some or a little of the time (1-2 days)**	**Occasionally or a moderated amount of time (3-4 days)**	**Most or all of the time (5-7 days)**
1. I felt my life had been a failure.	0	1	2	3
2. I felt fearful.	0	1	2	3
3. I felt that I was just as good as other people.	0	1	2	3
4. People were unfriendly.	0	1	2	3
5. I felt that I could not shake off the blues even with the help from my friends or family.	0	1	2	3
6. I was bothered by things that usually don't bother me.	0	1	2	3
7. I felt that everything I did was an effort.	0	1	2	3
8. I felt hopeful about the future.	0	1	2	3
9. I felt lonely.	0	1	2	3
10. I had trouble keeping my mind on what I was doing.	0	1	2	3

1. Do you own an iPhone or an Android cell phone?

   YES NO

   If yes, which one? _____

2. Do you have texting capabilities?

   YES NO

3. Do you have Internet capabilities?

   YES NO

Appendix B

EMA Questionnaire (Part 2)

1. Indicate to what extent you feel this way right now, that is, at the present moment.

a) Enthusiastic

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

b) Excited

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

c) Inspired

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

d) Upset

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

e) Scared

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

f) Nervous

Very slightly or not at all
A little
Moderately
Quite a bit
Extremely

2. Please indicate how stressed you are feeling on a scale from 0-10 (no stress to extremely high stress). _____

3. Within the last two and a half hours, have you eaten?

If yes, please provide a detailed list of any foods eaten AND the amount.

_____

What was your primary reason for eating?

a) coping
b) social
c) compliance
d) pleasure
e) physical
f) environmental
g) other _____

Where were you?

_____

Who were you with?

_____

4. Have you been physically active within the last two and a half hours?

a) yes
b) no

If yes, please list the activities AND the amount of time spent in each one.

_____

Where were you?

_____

Who were you with?

_____

5. Has something stressful happened to you within the last two and a half hours?

a) yes
b) no

If yes, please list the event(s). _____

Please indicate how stressful the event(s) was/were on a scale from 0-10 (no stress to extremely high stress). _____

Vita

Amy June Jeffers was born on December 22, 1987 in Virginia Beach, Virginia. She graduated from Salem High School in Virginia Beach, Virginia in 2006. She earned her Bachelor of Science in Psychology from Old Dominion University, Norfolk, Virginia in 2010. She began the doctoral program in Health Psychology at Virginia Commonwealth University in 2010.