INVESTIGATING PROXIMAL PREDICTORS OF INTRAINDIVIDUAL AFFECT VARIABILITY IN OLDER ADULTS

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To my late grandfather,

Joseph Fedorcsak

INVESTIGATING PROXIMAL PREDICTORS OF INTRAINDIVIDUAL AFFECT VARIABILITY IN OLDER ADULTS

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SUMMARY

The aging process is often coupled with major life changes such as retirement, death of friends and family members, and declines in physical and psychological functioning. Intuitively, any one or a conjunction of these events might be expected to lead to decreases in positive affect (PA) and increases in negative affect (NA). However, older adults tend to be emotionally positive and stable even late in life. Thus, it is possible that emotion-based strategies for coping with the challenges presented in later life can be used effectively by older adults, even amidst potential vulnerabilities in other domains.

The design of effective interventions and technologies aimed at facilitating this coping process will depend on understanding that emotions can influence health in different ways. Affect level and intraindividual variability (IIV) are independently related to distal factors such as personality and health-related outcomes such as immune functioning and mortality, among others.

By nature, emotions are subject to daily fluctuations that cannot be captured by investigation of mean affect levels alone. Research on affect IIV has focused primarily on whether there are stability differences in younger and older adults. In general, older adults tend to be more stable, perhaps because the failure to regulate emotions is particularly detrimental for older adults' physiological health. It is therefore important to understand how proximal factors in everyday life lead to intraindividual emotional changes.

The primary goal of this study was to identify the factors occurring within older adults' daily lives that predicted emotional deviations and to determine whether individuals differed in the types of factors that were emotionally-relevant. As such, it was imperative to employ a methodology that could differentiate the factors that evoked consistent emotional responses across all individuals from the factors whose impact on affect were person-dependent.

Specifically, participants were given online surveys three times per day for 20 consecutive weekdays that included assessments of their current positive and negative emotional states and questions (at least once per day) about their stress, pain, sleep quality, life space, physical activity, and social activity. Multilevel modeling (MLM) was used to determine if there was significant affect IIV for these older adults and how much IIV could be explained by these proximal predictors. This analysis approach was used because it is well-suited for nested data (in this case, observations nested within-persons) and does not assume independence of observations (which is a concern when individuals receive repeated assessments). Additionally, MLM analyzes the complete dataset rather than complete cases (individuals), which allowed for comparison of fixed effects regression models and random effects regression models. Random effects models, which are the hallmark of MLM, enabled the analysis of potential individual differences in the within-person relationships between the predictors and affect.

As expected, there was significant affect IIV in these older adults for both PA and NA. The predictors of PA and NA were analyzed first in isolation (referred to as “isolated models”) and then when controlling for the other proximal variables (referred to as “full models”). The random effects isolated models were generally better fitting than the fixed effects isolated models, indicating that the models that did not constrain individual predictor-affect slopes to be the same across persons (random) were more accurate representations of the observed data than models that constrained individuals’ slopes to be the same (fixed).

Full fixed slopes and full random slopes models were built in stepwise fashion based on the results of the isolated models. Again, the random effects full models better fit the observed data than the fixed effects models for both PA and NA, providing strong evidence in favor of the hypothesis that a larger percentage of affect IIV would be explained when allowing individual differences in the within-person predictor-affect relationships. The full random models accounted for 32% of the PA IIV, and 45% of the NA IIV. These were both better fitting than their respective null models, indicating that overall, the proximal predictors accounted for significant proportions of the within-person PA and NA variance.

Certain factors accounted for larger percentages of the IIV than others and in general, there were differences between the PA and NA model in terms of which factors led to emotional fluctuations. Subjective health accounted for the largest percentage of PA IIV and stress accounted for the largest percentage of NA IIV. Additionally, subjective health, life space, stress, and pain were significant *unique* predictors of PA, NA, or both. However, there were specific unique effects across both PA and NA, namely, the slope variances for stress and pain. Follow-up analyses were unable to account for these slope variances using person-level predictors. In essence, an individual's emotional reactivity to pain and stress did not depend on his or her overall mean level of those factors, or of the other daily predictors. This provided further evidence that PA and NA should be treated as separable variables (e.g., it is possible for a daily event to decrease older adult's positivity without necessarily increasing their negativity) but also highlighted factors that have pervasive influences on emotion regardless of valence, which is harmonious with models of affect that propose a dynamic relationship between PA and NA.

The results from this study have theoretical and practical implications. Theories on emotional stability often focus on if and why older adults are more stable than younger adults. Findings of the present study both support and expand upon these theories by identifying within an older adult population, which proximal factors were likely to cause emotional deviations after partialling out the effects of other daily variables, including factors that were previously unstudied in this domain. The analysis methodology implemented in the present research

allowed for direct investigation of whether certain individuals were more prone to the influences of these factors than others. These results are discussed in the context of coping and resiliency theories that posit individual differences in emotional responses to stimuli based on these capabilities. From a practical perspective, these results highlight that the design of interventions and technologies intended to provide older adults with effective skills and resources to maintain or improve their emotional well-being should be tailored to individuals' affective profiles.

CHAPTER 1

INTRODUCTION

The population of older adults (ages 65+) in the United States is rapidly growing and at the same time, life expectancy continues to increase (Health & Services, 2012). By the year 2030, nearly 20% of the U.S. population will comprise older adults (Health & Services, 2012). This demographic prefers to age in place, and there is evidence that preserving autonomy throughout adulthood has health benefits (Mitzner, Chen, Kemp, & Rogers, 2014). Yet, inherent in the aging process are declines in physical and cognitive functioning, which can make maintaining autonomy difficult (Fausset, Kelly, Rogers, & Fisk, 2011; Greiner, Snowdon, & Schmitt, 1996). Despite these age-related deficits in a variety of domains, as a group, older adults tend to maintain positive attitudes regarding their subjective well-being, which has been referred to as the well-being paradox (Charles & Carstensen, 2010).

Subjective well-being has been proposed to comprise two main components; trait and state. The trait component is referred to as life satisfaction, and reflects relatively stable evaluations of one's life as a whole (Diener, 2000). The state component is affect, which is positive and negative emotional evaluations that are subject to fluctuations as a result of daily events and stressors (Diener, 2000). Distinctions are sometimes made between affect, emotion, and mood but with little consensus on how exactly they differ (Ekman & Davidson, 1994) so these terms will be used interchangeably in this paper.

Affect is linked to a number of physical and psychological health-related domains, however, much of the research on the relationship between health and affect has focused on mean levels of affect (Fredrickson, 2000; Pressman & Cohen, 2005; Steptoe, Wardle, & Marmot, 2005; Watson, Clark, & Tellegen, 1988). This fails to capture the short-term fluctuations within a person that are inherent in the affect component of subjective well-being and are largely independent of mean levels of emotion (Chow, Ram, Boker, Fujita, & Clore, 2005; Kashdan & Rottenberg, 2010). To understand these fluctuations, frequently repeated assessments of affect must be administered and analyzed in terms of a person's variability rather than mean levels. Although there are various indices of within-person variability (Gruber, Kogan, Quoidbach, & Mauss, 2013; Ong & Zautra, 2014), individual variations in affect are consistently associated with health-related processes such as sleep (Mccrae et al., 2008; Ong et al., 2013) and outcomes such as anxiety (Gruber et al., 2013) and mortality (Mroczek et al., 2015). As a result of the unique relationship between emotional variability and these processes and outcomes, and with advances in statistical techniques to model within-person changes (Hertzog & Nesselroade, 2003), increasing attention has been given to the study of within-person emotional fluctuations (Boker, Molenaar, & Nesselroade, 2009).

Further contributing to the paradox of well-being, in addition to maintaining high levels of subjective well-being into adulthood, older adults tend to fluctuate less in affect than younger adults within and across days (Röcke, Li, & Smith, 2009). However, this does not imply that all older adults' emotions are completely stable. What is less understood is the extent to which older adults show short-term variability in affect and what predicts this lability within an individual. Identifying the predictors of affect variability within older adults will not only advance theories of emotion in this demographic, but will also prove useful in the development of personalized methods that allow individuals to (a) monitor their emotional states, (b) understand instances in which those states are likely to deviate, and (c) potentially adjust their environment or behavior to better regulate their emotions.

Recently, health-monitoring technologies are becoming increasingly popular ways by which people manage and maintain their *physical* well-being (Bujnoch, 2011). Some of the capabilities of these technologies include sensors that track physical activities (e.g., steps, miles run, hours spent standing) and physiological states (e.g., blood pressure, heart rate). *Emotional* well-being, in contrast, cannot be passively monitored using these sensors, and instead would require an individual to input information into the system regarding their mood. The benefit of implementing such a feature would be that feedback could be given to users on how their amount of daily exercise contributes to their level of happiness, for example. Although there is conflicting evidence on whether affect variability is adaptive or maladaptive (Röcke & Brose, 2015), providing users of these technologies with individualized information on what predicts their emotional variability could allow them to see, or even alert them, if they begin fluctuating outside their average oscillatory window (Chow et al., 2005), so to speak.

Receiving personalized emotional feedback also has the potential to improve emotional clarity, defined as the ability to understand and differentiate between one's own emotions (Boden, Thompson, Dizén, Berenbaum, & Baker, 2013; Palmer, Donaldson, & Stough, 2002). This understanding of emotional states can likely be bolstered by knowledge of the immediate predictors of deviations in those states. Because lower emotional clarity predicts greater depression and anxiety, and worse mental health, vitality, and physical functioning (Extremera & Fernández-Berrocal, 2006), increasing one's own awareness of their emotional variations could lead to improvements in psychological and physical health.

Affect Level and Variability Relate to Health

The state components of subjective well-being, Positive Affect (PA) and Negative Affect, (NA) have been shown to be only modestly correlated with each other, suggesting that they are not opposite ends of a bipolar spectrum, but instead represent two separable aspects of emotional experiences (Watson et al., 1988). To illustrate, it is possible to experience a component of Positive Affect (excitement, alertness, etc.) concurrently with a component of Negative Affect (fear, nervousness, etc.) and in dynamic models of affect (DMA) it is suggested that the interplay between these two components is contextually dependent (Zautra, Smith, Affleck, & Tennen, 2001). As such, PA and NA levels have been shown to be differentially related to physical and psychological health.

Higher mean PA is associated with increased immune function and cardiovascular health, longevity, and less intense self-reported pain levels (Steptoe et al., 2005). Conversely, higher mean NA is associated with decreased immune function and cardiovascular health, more depressive symptoms, and increased cortisol levels (Steptoe et al., 2005). Although the relationship between health and mean levels of Positive and Negative Affect justify these constructs as ones that warrant study, focusing solely on *inter*-individual differences in affect level limits understanding of the nature of emotions. For example, one individual's PA might fluctuate often throughout the day, resulting in multiple occurrences of both high and low PA at different times, whereas another individual with an identical mean level might not experience extreme highs or lows and have a more intermediate, but stable PA profile (Gruber et al., 2013). See Figure 1 for an illustration. Thus, examining the relationship between health and mean levels of affect yields an insufficient understanding of the complicated dynamics involved in people's emotions.

A more recent direction in the investigation of human emotion is on *intra*-individual variability (IIV) in affect (Eid & Diener, 1999; Röcke et al., 2009). Investigating IIV in general is of particular interest in the study of aging, as it provides an understanding of temporal patterns and allows for an establishment of deviations from individual baselines that might be indicative of internal changes (Hertzog, Dixon, & Hultsch, 1992). The importance of analyzing IIV has been identified regarding cognitive functioning (Hertzog et al., 1992) and physical functioning (Nakamura et al., 1997). IIV in cognition may be an indicator of compromised internal mechanisms involved in disease and injury (Burton, Hultsch, Strauss, & Hunter, 2002). Also, previous research has shown that individuals with mild dementia show greater reaction time IIV in cognitive performance assessments than healthy and arthritic older adults (Burton et al., 2002). In the context of physical functioning (balance/gait, blood pressure, etc.), individuals with Alzheimer's disease show elevated IIV compared to healthy adults (Nakamura et al., 1997).

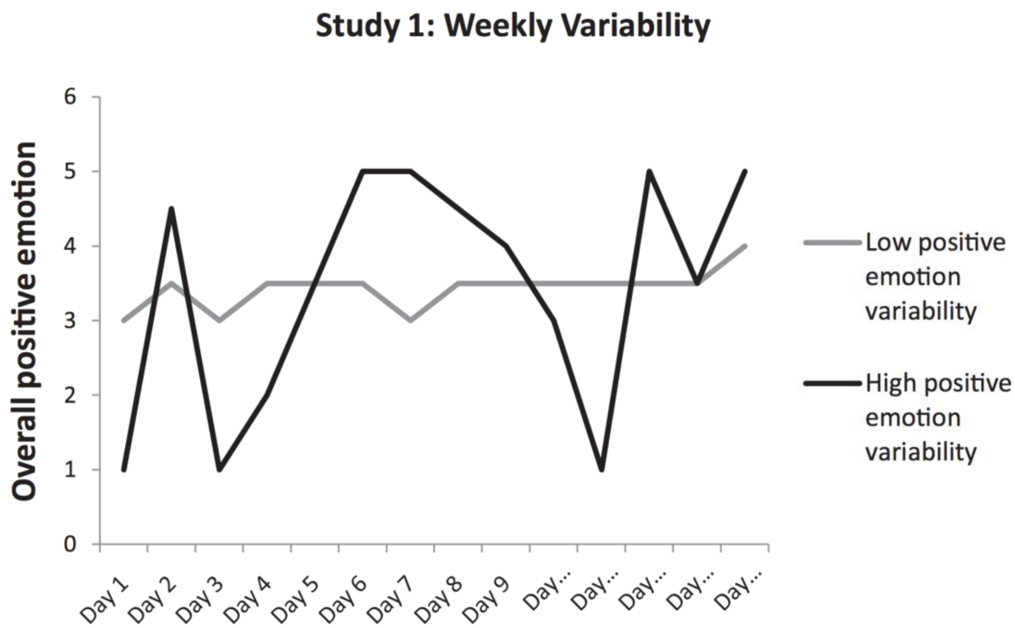

Figure 1. Sample data from two participants showing emotion level across days (Gruber et al., 2013). The black line represents an individual with high positive emotion variability across days. The gray line represents an individual with low positive emotion variability across days. Although they clearly have different emotional profiles, these two participants had identical mean levels of positive emotion (*M* = 3.43), highlighting the importance of studying intra-individual variability in affect.

In affect, the study of IIV provides insights into the complexities of human emotion. Affect IIV has been shown to be largely independent of mean affect levels, yielding only small positive correlations (Chow et al., 2005). A person's variability in affective states tends to operate as a trait, such that the degree of within-person variation is relatively stable over time (Eid & Diener, 1999). Although there is some evidence that greater variability in affect is beneficial to psychological health and well-being (Kashdan & Rottenberg, 2010), more evidence seems to support the claim that greater variability is associated with worse psychological health above what can be explained by overall mean emotion levels (Gruber et al., 2013). In fact, higher *variability* in positive emotions leads to decreases in life satisfaction and physical functioning, and increases in symptoms of depression and anxiety, whereas higher *level* of positive emotions shares an inverse relationship with these variables (Gruber et al., 2013).

Affect IIV shows strong associations with trait variables and distal outcomes. For example, greater deviations in PA in response to stressors doubles risk of mortality (Mroczek et al., 2015). In NA, higher variability is associated with increased depressive symptoms and neuroticism (Waugh, Thompson, & Gotlib, 2011), and has been used to screen individuals for bipolar affective disorders (Depue et al., 1981). Extraversion predicts variability in certain positive emotions such as joy, and neuroticism predicts variability in other positive emotions such as happiness and love (Eid & Diener, 1999). Interestingly, mean affect levels together with personality traits explain only 10% of the IIV in positive affect and 52% of the IIV in negative affect (Eid & Diener, 1999). Given affect IIV's association with mortality, and that only small to moderate amounts of the variability in affect can be explained by personality traits and mean levels, further investigation of what leads to affect IIV can enhance our understanding of emotions.

Some consistency in the variability in affect can be explained by endogenous factors, and PA in particular shows consistent diurnal variation. Upon waking, PA tends to increase throughout the day until sometime in mid- to late-afternoon, and then decreases until bedtime (Steptoe, Dockray, & Wardle, 2009). Affect IIV can also be influenced by exogenous factors, such as stressful events. Cortisol shows an inverse relationship with PA over the day and lower levels and greater variability of PA in the afternoon lead to higher cortisol concentrations in the evening (Simpson et al., 2008). Furthermore, greater reactivity in positive affect in response to daily stressors is associated with impaired sleep (Ong et al., 2013). These findings highlight that variability in affect is associated with important health-related processes and outcomes.

In a study that directly investigated within-person NA and PA intraindividual variability (operationalized here as the intraindividual standard deviation (iSD)), college students' PA variability showed significant positive relationships with social activity and exercise, and a negative relationship with physical complaints (Watson et al., 1988). When split into quartiles, the relationship between PA variability and physical complaints was strongest for individuals in the third and fourth quartiles (Watson et al., 1988), such that people who reported a greater number of physical complaints varied more within themselves in PA. Contrastingly, NA variability was negatively correlated with social activity, and was positively correlated with perceived stress and physical complaints. Similar to PA, when split into quartiles, those in the third and fourth physical complaint quartiles showed greater NA variability (Watson et al., 1988). Of note is that although the iSD is a widely used univariate index of affect IIV, this approach provides a somewhat limited scope of emotional variability that can be broadened by using more sophisticated methods (Larsen & Diener, 1987; Ong & Zautra, 2014). Approaches such as multilevel modeling, for example, more accurately estimate within-person variance and can also estimate the covariance between repeated assessments of affect and the daily activities and health-related variables mentioned in this section.

In sum, positive and negative affect are two related, yet separable components of well-being. Higher mean levels of PA, and lower mean levels of NA have been shown to be associated with a variety of health-related outcomes. Affect IIV taps into a distinct part of the subjective emotional experience, shows consistent daily patterns, and is trait-like in nature, such that individuals show characteristic variability over time (Eid & Diener, 1999). In general, greater affect IIV is linked to negative outcomes such as higher mortality risk, impaired sleep, and increased stress and physical complaints, but some evidence suggests that greater variability might also be related in a positive manner to social activity and exercise (Watson et al., 1988). The relationship between health and affect IIV and health and affect level tend to be inverse, such that higher level and lower variability are linked to more beneficial health outcomes (Gruber et al., 2013). However, many of the findings on the factors that relate to affect IIV have been observed only in younger adult samples and sometimes have used methods that do not fully capture the nuances of emotional variability. It is not fully understood how these potential relationships operate in older adulthood.

Affect IIV in Older Adults

The aforementioned well-being paradox is that mean affect levels are largely maintained throughout adulthood, despite age-related declines in physical and cognitive functioning. There is also a substantial amount of evidence that older adults show significantly less affect IIV compared to younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Carstensen et al., 2011; Neupert, Almeida, & Charles, 2007; Röcke & Brose, 2015; Wolff, Schmiedek, Brose, & Lindenberger, 2013). In day-to-day reports of affect, more variability exists in PA than in NA for both younger and older adults, but older adults vary less than younger adults do across both domains (Röcke et al., 2009). Given evidence that older adults are more stable than younger adults and that stability may be adaptive, the study of affect IIV is a particularly intriguing area for research on aging, a discipline in which age-related differences are typically associated with declines. Although the relative preservation of the emotional system in older age is cause for optimism, it is crucial to identify the mechanisms that might lead to this preservation and the instances in which the system fails.

One proposed mechanism that may underlie age-related differences in affect variability is the *environment*; older adults' daily life contexts are less varied than younger adults'(Fleeson & Jolley, 2006). The notion is that older adults show less affect IIV because their lives are less susceptible to events that could impact their mood. However, it is unclear if within an older adult population, those who actively introduce variation into their daily life contexts are more likely to experience variability in their affect. Some potential ways of actively introducing variation are through physical activity, social activity, or general life space, which is defined as the distance a person travels relative to his or her sleeping location (Peel et al., 2005).

Another proposed mechanism is *experiential and learning-related processes*; having lived longer, older adults have become more habituated to daily events, which makes them less likely to impact their mood (Fleeson & Jolley, 2006). Indeed, when daily events do occur, older adults exhibit comparatively less of an emotional reaction than younger adults do, such that when a negative event occurs, younger adults' PA shows a greater decrease and when a positive event occurs, younger adults' PA shows a greater increase (Röcke et al., 2009). NA reactivity in response to daily stressors is also less pronounced in older adults (Brose, Schmiedek, Lövdén, & Lindenberger, 2011), but can depend on factors such as the personal control beliefs of the individual (Neupert et al., 2007), which may themselves have been acquired as a result of life experiences.

These findings are in line with a leading theory of aging and emotion, the socio-emotional selectivity theory (SST), which hypothesizes that with age comes a greater drive to maintain positive emotions and well-being, and so older adults tend to focus more on positive information than on negative information (Carstensen, Isaacowitz, & Charles, 1999). For example, older adults report less emotional reactivity than younger adults in response to encounters of interpersonal conflict (Birditt, Fingerman, & Almeida, 2005), and so social activity may not be a significant source of emotional variability for many older adults. Furthermore, Building upon SST, the strengths and vulnerability integration theory (SAVI) posits that one of the reasons why older adults devote substantial cognitive resources to regulating their emotions is because there are severe physiological costs for failures to avoid or regulate negative experiences, specifically in the cardiovascular and neuroendocrine systems (Charles & Luong, 2013). As such, identifying the situations or potential experiences that predict significant changes in (or failures to regulate) emotional states is especially important in older adulthood.

Emotional reactivity (i.e. the inverse of emotion regulation) is typically operationalized as the extent to which a person's positive and negative affect deviate in response to stimuli that are positively (e.g., pleasant imagery, rewards) and negatively (e.g., unpleasant imagery, stressful tasks) valenced, respectively (Bylsma, Morris, & Rottenberg, 2008). However, attending individuals to emotional stimuli forces emotional responses and consequently, this method may not be capturing regular fluctuations in affect that occur in daily life. Additionally, appraisal (i.e. how a person evaluates a situation) is a critical component of emotion regulation (Urry & Gross, 2010), so certain daily events or changes in health throughout the day might not elicit the same reactions in different people. Thus, to fully understand the normal ebb and flow of affect in daily life (not necessarily emotional reactivity to specific stimuli), frequent assessments of affect and the potential proximal predictors of affective changes must be administered over time within individuals, and it is critical to implement methods that enable analysis of individual differences in the within-person predictor-affect relationships.

Assessing the Proximal Predictors of Older Adults' Short-term Affect IIV

Intraindividual variability in affect tends to decrease over the course of life. However, variability still exists in older individuals, is influenced by personality, stressors, and endogenous rhythms, and can lead to distal health outcomes such as mortality. Additionally, the physiological costs of sub-optimal regulation of emotions may be more substantial for older adults than younger adults. To be able to identify and prevent instances in which older adults' emotional stability is likely to be compromised, it is essential to understand the extent to which affect IIV is influenced by other proximal variables such as daily or weekly perceptions of health (objective, pain, sleep, subjective) and daily activities (life space, physical, social). To inform the design of interventions and technologies aimed at maintaining well-being, it is critical to implement methods that can shed light onto how frequently these assessments should be administered, can account for the covariation of affect and proximal predictors, and can provide insights into which relationships persist between-persons versus those which are subject to individual differences. Thus, the primary focus of this study is to address the following questions:

Q1: Is there a significant amount of affect IIV in generally healthy older adults?

Q1.1: How frequently does it vary (i.e., how often should affect be assessed)?

Q2: Is affect IIV accounted for by proximal daily factors such as:

- Health perceptions (pain, stress, subjective health, sleep, weekly objective health)?
- Daily activities (life space, physical, social)?

Q2.1: Are certain factors more predictive of PA IIV? Of NA IIV?

Q2.2. Are there individual differences in the factors that predict affect IIV?

These questions lead to several specific hypotheses:

H1: These older adults will have significant intraindividual variability in both positive and negative affect.

H2: Health perceptions will significantly explain intraindividual variability in positive and negative affect.

H3: The factors that significantly predict affect IIV will differ between individuals.

Although affect IIV tends to decrease with age, Hypothesis 1 is based on the premise that although IIV may be reduced, there may still be significant variance. Hypothesis 2 is based on the aforementioned evidence suggesting that affect IIV is linked to psychological and physical health. Thus, it makes sense that pain, stress, sleep quality, and health ratings would predict variability in affect. Hypothesis 3 was formulated based on findings that affect IIV reliably operates as a trait-like variable (Eid & Diener, 1999), and that individual emotional profiles can vary between-persons (Gruber et al., 2013) so it follows that different individuals' affect may vary differently in response to the same factor.

Specific hypotheses regarding daily activities cannot be made from the extant literature. Theories regarding why affect variability decreases as people age suggest that older adults' daily environments may be low in variability or that older adults have become more capable of regulating their emotions as they have aged. It is possible that for some older adults, on days with a more variable environment than they were accustomed to (e.g., if social activity was high on a given day), their affect might be much higher (or much lower) than their own average. Conversely, if over time older adults have become experts at regulating their emotions, daily activities might not significantly influence affect. Another explanation could be that these activities are the means by which older adults regulate their affect, and perhaps daily activities are maladaptive for certain people and adaptive for others. Thus, I expected to find between-person differences in the within-person relationships with affect. This investigation provided insights into older adults' emotional experiences, and could guide the development of interventions or technologies that help older adults be made aware of emotional variability and maintain stability, and as a result, enable the potential for a more successful aging process.

CHAPTER 2

METHOD

Participants

63 independently living older adults were recruited from the Human Factors and Aging Laboratory participant registry and by word of mouth. Individuals were excluded from participation if they did not have access to the internet in their place of residence, as the method of assessment was via online surveys (surveymonkey.com). No other recruitment exclusions were made. Four participants' datasets were excluded from analysis based on survey response behaviors that violated the instructions given by the experimenter (described later in the Procedure section), bringing the final sample size to 59 with ages ranging from 65-80 years (M = 73.34, SD = 4.69).

Demographic, health, and technology experience information was collected using standardized materials developed by the Center for Research and Education on Aging and Technology Enhancement (CREATE; Czaja et al., 2006). Of the final 59 participants, 34 (57.6%) were female and 25 (43.4%) were male. The participants were generally healthy, diverse in race/ethnicity, well-educated, and had a general breadth score mean of 21.95 out of 36 technologies (see Table 1).

Table 1. *Participants' Demographic, Health, and Technology Experience*

Factor	Measure	Mean	Standard Deviation	Range
General Health[a]	"In general, would you say your health is…"	3.52	0.87	2-5
Technology Experience[b]	General Breadth Score	21.95	6.25	6-34
Race/Ethnicity (%)	Black/African American White Multi-Racial Other/No response given	24% 64% 3% 9%		
Education (%)	High School Graduate Vocational Training Some or in-progress college/Associate's degree Bachelor's degree Master's degree Doctoral degree	3% 3% 30% 35% 21% 5%		

a: 1 = poor, 3 = good, 5 = excellent
b: 0 = not used , 1 = used

Materials

Daily Assessments – Survey Monkey

Daily questionnaires were administered using Survey Monkey (www.surveymonkey.com). Participants filled out three surveys per day for four weeks, not including weekends (20 days, 60 surveys). Weekends were not included because I expected those days to be too dissimilar to weekdays for some people, and inflate the within-person variance in the survey responses in a way that would obscure interpretation of the results. The three surveys were emailed to participants each day at different time points (morning, afternoon, and night). Each survey differed slightly, but contained the same key items.

Affective States

Affective states were assessed using the International Positive Affect Negative Affect Schedule (PANAS) Short Form (I-PANAS-SF; Thompson, 2007). This 10-item assessment consists of five positive (e.g., alert, inspired) and five negative (e.g., afraid, upset) emotions (see Table 2). Participants indicated on a 5-point scale (1 = not at all, 5 = extremely) the extent to which they felt these emotions *at the present moment*, three times a day (morning, afternoon, night). These were the first ten items in every survey, and were presented in random order each time.

Table 2. *International Positive Affect Negative Affect Schedule – Short Form*

Positive Affect	Negative Affect
Active	Afraid
Alert	Ashamed
Attentive	Hostile
Determined	Nervous
Inspired	Upset

Perceived Pain

Perceptions of physical pain were assessed using a single item: “To what extent to you feel physical pain at the present moment?” This question was administered three times per day in the same response format as the I-PANAS-SF.

State Stress

Stress was assessed three times per day using a single-item: “To what extent do you feel stressed at the present moment?” Responses were made on the same 5-point response scale as the I-PANAS-SF.

Subjective Physical Health

Subjective physical health (which will be referred to as “subjective health”) was assessed each afternoon using three questions in the same format and response scale as the I-PANAS-SF. This measure was developed for this study and asked participants to indicate the extent to which they felt 1) physically healthy, 2) physically strong, and 3) physically rested.

Objective Physical Health

Objective physical health was assessed *weekly* during the Friday afternoon questionnaire using the 10-item physical functioning sub-section of the SF-36 (Ware Jr & Sherbourne, 1992). Objective health assessments have been shown to be less indicative of actual health than subjective health assessments (Idler & Benyamini, 1997), so this was only assessed weekly to minimize the amount of time required to complete the daily battery and because it was not expected to vary significantly on a daily basis. Participants were asked if their health limited them in specific activities (e.g., lifting or carrying groceries, climbing a flight of stairs) over the past week. Response options were 1) Yes, limited a lot 2) Yes, limited a little 3) No, not limited at all.

Sleep

Participants were asked two questions regarding their sleep during the morning assessment only. The first question, "What time did you wake up today?" allowed for a better idea of when in a persons' day they completed the surveys to guide decisions on when to exclude (or not exclude) certain survey response occasions. For example, I did not want to discount a Morning survey that was completed in the afternoon if the person had woken up after 12:00pm, because the response would be during their "morning". The second question, "How well did you sleep last night?" assessed sleep quality. This question was adapted from the single-item Sleep Quality Scale (Cappelleri et al., 2009). Responses were made on a 5-point scale ranging from 1 (worst possible sleep) – 5 (best possible sleep).

Physical and Social Activity

Participants were asked how much time they spent engaging in 1) physical activity and 2) social activity. Participants were asked to round to the nearest half hour, and to consider the entire day when responding, from the time they woke up until the time they expect to go to bed. Each of these questions were asked once per day, during the Evening assessment. Additionally, these questions were asked during Friday's Afternoon assessment, but was "this past week…" rather than "this past day…". The "past day" question was of primary interest, with the "this past week" question asked mainly as a check to see how close it was to the aggregate of the week's "past day" responses. Due to concern about daily assessments becoming too lengthy, this question format captured the time spent doing these activities, but did not ask for the specific types of activities from which participants base their responses.

Life Space

The extent of the participants' movement within different contextual levels (e.g., in their home, in the community) was assessed using the Life Space Assessment (Peel et al., 2005) as an indicator of the participants' daily environments (see Figure 2 for a conceptual model). This assessment was adapted to a 5-item checklist (one for each level) "During the past day, have you been… 1(outside your bedroom), 2(outside your home but within your neighborhood), 3(places in your neighborhood other than your own yard or apartment building), 4(places outside your neighborhood but within your town), 5(places outside your town). This was administered during the evening questionnaire only.

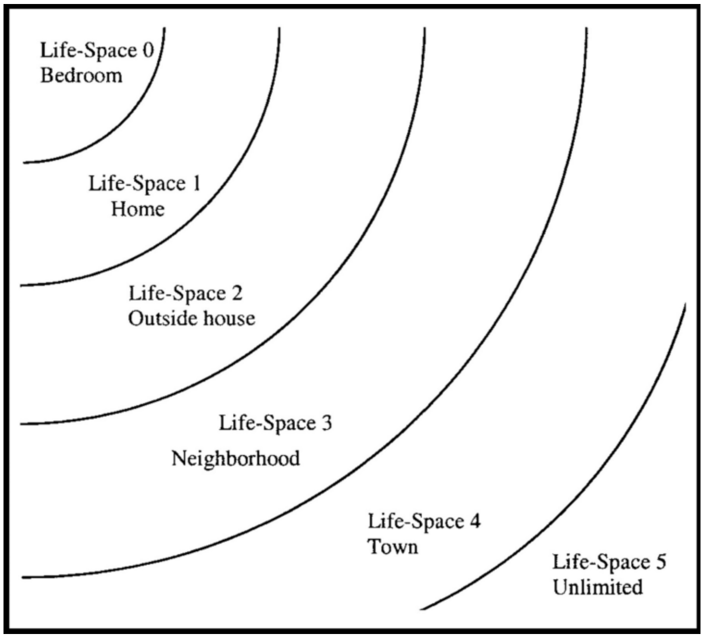

Figure 2. Conceptual model of life space (Peel et al., 2005).

Typical Week

To determine whether participants had an abnormal week (which may have impacted their survey responses), a single question was administered during the night assessment: “To what extent was this past week and typical week for you?” Responses were made on the same 5-point response scale as the I-PANAS-SF.

Initial and Final Assessments

The following assessments reflect trait-like measures of the variables of interest in the present study, and were administered (also via SurveyMonkey) to obtain baseline information for each participant, and will allow for comparisons between these characteristics before and after the one-month survey period. As trait-like factors, these were not expected to change significantly over the survey period, but if for example, satisfaction with life changed for those who experience high affect IIV, analysis of those effects could inform future research but were not included as predictors in the analyses that follow. Appendix A contains the full initial survey except for the Trait Anxiety Inventory (only the first four of twenty questions are presented here due to copyright purposes). Appendix B contains the descriptive results of the initial survey. The questions asked in the final survey were identical, except the demographic-type variables, items 2-18 (age, gender, occupation, education, etc.), were not reassessed. Additionally, the final survey contained six unique open ended questions (Appendix F).

Demographic, Health, and Technology Experience Questionnaires

Demographic, health, and technology experience information was collected using standardized materials developed by the Center for Research and Education on Aging and Technology Enhancement (CREATE; Czaja et al., 2006).

Personality

The 10-item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 2003) was also be administered. More extensive personality inventories exist, but because personality was not of primary interest for this study, the TIPI was sufficient for these purposes. Participants responded on a scale of 1 (Disagree strongly) to 7 (Agree strongly) the extent to which pairs of ten traits (e.g., critical/quarrelsome, sympathetic/warm) applied to themselves.

Satisfaction with Life

Participants' global well-being was assessed using the Satisfaction With Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985). This 5-item questionnaire contains questions regarding a person's feelings about their life as a whole. Response options ranged from 1 (strongly disagree) to 7 (strongly agree).

Trait Anxiety

The trait components of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) were administered as a measure of trait anxiety. This scale consists of 20 statements that participants responded to on a 4-point scale, 1 (almost never) – 4 (almost always) regarding how people typically feel (e.g., secure, inadequate).

Trait Stress

The Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) was administered as a measure of trait stress. This 14-item scale asked participants to respond to questions about stress and coping such as "In the last month, how often have you been able to control irritations in your life?" on a 5 point scale (0 = never – 4 = very often).

Affect Intensity

Participants also completed the Affect Intensity Measure (AIM; Larsen, 1984), which is a trait assessment of the magnitude of people's typical positive and negative affective states. Respondents were asked to indicate the extent of their agreement with statements such as "When I am happy, the feeling is one of intense joy" and "When I am nervous I get shaky all over." Responses ranged from 1 (Never) to 6 (Almost Always).

Procedure

After recruitment, participants were sent an email that included the date and time when they would be called for Day 1 of the research study, a copy of the consent form, and their username, which they would enter at the beginning of every survey. Day 1 of the research study was a "guided practice" session, for which the researcher would call the participant on the phone. The participant would first read an electronic version of the Informed Consent via a SurveyMonkey.com link and were instructed to click "Next" at the end of the form if they understood their rights as research participants and agreed to be in the research study. Clicking "Next" directed the participant to a version of the daily survey (contents explained below). Participants were instructed to complete the survey while the researcher stayed on the phone to be available for any questions the participants had. After completion of the practice survey, the phone call ended and the participants were emailed another SurveyMonkey link to fill out the Demographics, Health, and Technology Experience Profile, the Satisfaction with Life Scale, the Ten Item Personality Inventory, the Affect Intensity Measure, the Trait component of the State-Trait Anxiety Inventory, and the Perceived Stress Scale.

On Day 2, the researcher would again call the participant, confirm that they completed the survey with the Demographics, Health, etc., and then do another guided practice session with a slightly different version of the daily survey. These surveys together included every question that the participants would receive in the subsequent daily surveys, so they saw every question at least once prior to beginning the survey and were encouraged to ask for clarification if any of the questions were confusing or difficult to answer. These days were for participant practice only, and the data collected was not saved or included in data analysis. To reduce the chance of forgetting what was taught during the practice phase, days 1 and 2 occurred no more than 3 days apart, and Day 2 occurred no more than 3 days prior to actual data collection, which was always on the following Monday, Day 3 of the study.

On Days 3-23, participants received an email three times per day (morning, afternoon, evening) with a Survey Monkey link to the corresponding survey that they then completed online. The Morning survey (Appendix C) was sent at 6:00am, the Afternoon survey (Appendix D) at 12:00pm, and the Evening survey (Appendix E) at 6:00pm EST. Participants were instructed to complete each survey before the next survey came in, and to space out the surveys out as best they could. The morning questions consisted of the I-PANAS-SF, Current Stress, Current Pain, and the two Sleep questions. The afternoon questions differed in that instead of the two Sleep questions, Current Subjective Health was assessed. Note that Past Week’s Objective

Health was assessed during the afternoon only once per week (Fridays) in attempt to keep the surveys as brief as possible. The evening survey differed in that it did not include Sleep or Subjective Health, but included the Life Space, Daily Physical Activity, and Daily Social Activity assessments.

On Day 24 of the study, following the evening survey, participants received the final assessments, similar to those received on Day 1(see Appendix F for the questions unique to the final survey), and were instructed to complete the final survey within one week. At the conclusion of the experiment, participants were debriefed and compensated for their time. An overview of the procedural flow and main assessments at each of the three daily survey points can be seen in Figure 3.

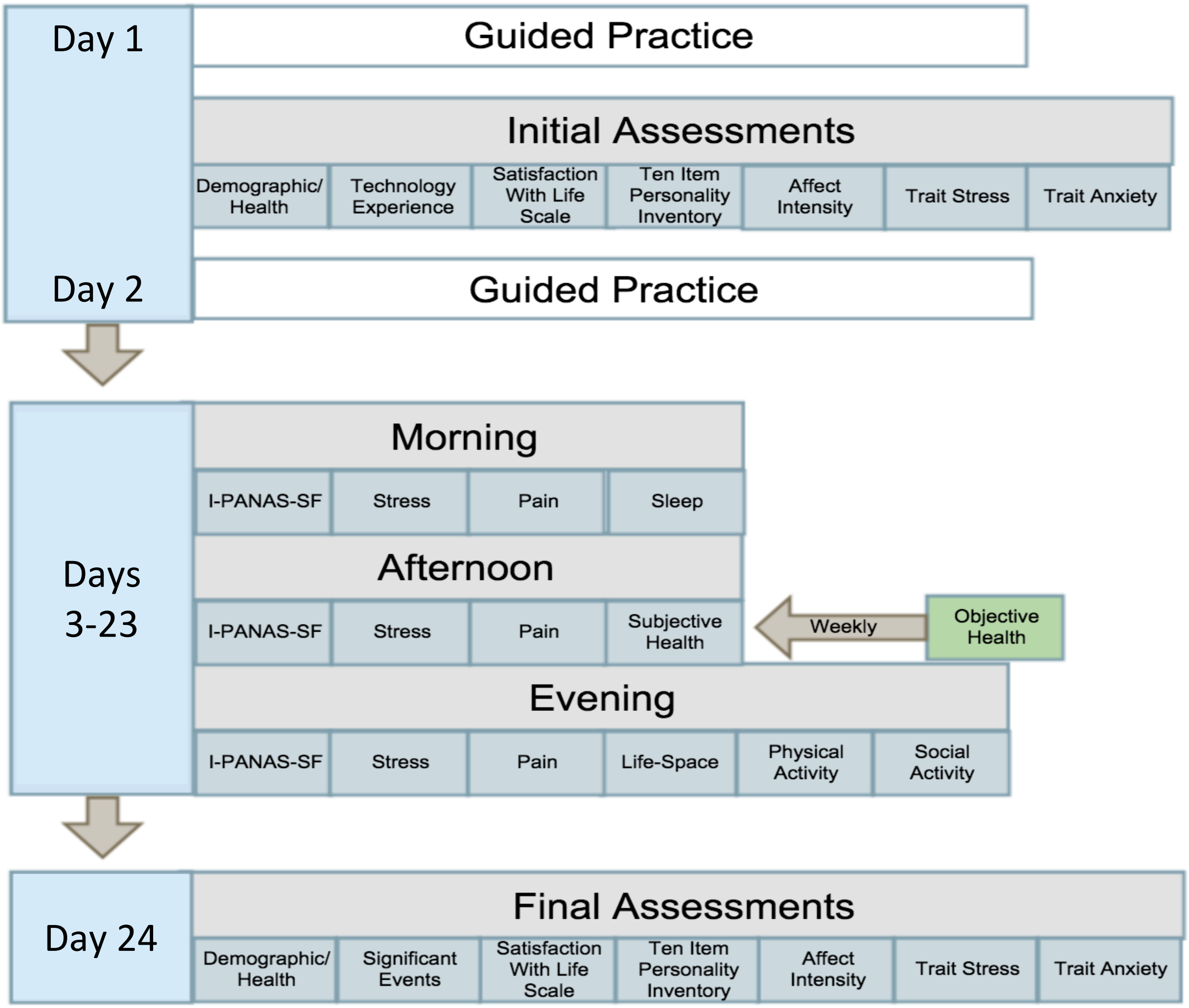

Figure 3. Study procedural flow.

CHAPTER 3

RESULTS

Analysis Overview

Of the 59 participants included in analysis, there were a total of 3540 possible survey responses (59 people x 60 observation points). The total number of surveys completed by these participants was 3420 (96% of all possible surveys). However, in addition to the 4 participants who were excluded based on violation of the rules provided, I implemented a "Strict" post-hoc rule for valid surveys. The "Strict" rule was as follows:

1. <u>Surveys must be completed in order</u> (e.g., the Evening survey had to follow the Afternoon survey). The 3 different survey links were emailed to the participants every day at the aforementioned times, but the links themselves did not change, so participants had access to each survey at all times. Participants were intentionally not told about this access (which was due to a limitation in SurveyMonkey) and in general, they followed the intended structure. This rule was meant to correct the infrequent occasions on which the intended structure was not followed.
2. <u>There must be at least a 1 hour gap between surveys on each day</u>. It was possible for participants to complete the Morning survey at 11:59am and the Afternoon survey at 12:00pm, for example, and still technically be within the initial rules provided to them. Thus, this post-hoc rule was meant to preserve the spacing between measures of affect so a more accurate estimate of the within-person variability would be obtained.
3. Surveys must be within the 6 hour "windows" provided (based on wake-up time). The "What time did you wake up this morning?" variable was used to determine each person's window to complete the surveys on each day. For example, a person with an

11am "Wake-up time" would have from 11am-5pm to complete their "Morning" survey. This rule was made to maintain the "Morning", "Afternoon", and "Evening" collection points, while not penalizing participants whose sleep schedules were not conducive to the 6am, 12pm, 6pm structure provided by the experimenters. Of interest for this research study was not necessarily what time of day the participant completed the survey, but instead *at what point in that participant's day the survey was completed*.

Of the 3420 completed surveys, 176 responses were invalid based on these "Strict" rules. The total number of surveys included in subsequent analyses was 3244 (91.6% of the total possible surveys completed). Descriptive information for the primary variables of interest are presented in Table 3.

Table 3. *Descriptive Statistics for Daily Assessments*

Factor	Measure	Mean	Standard Deviation	Range
Positive Affect[a]	5 PA items; 3x/day	3.11	0.77	1-5
Negative Affect[a]	5 NA items; 3x/day	1.15	0.35	1-3.50
Physical Pain[a]	Single item; 3x/day	1.65	0.88	1-4.67
State Stress[a]	Single item; 3x/day	1.45	0.74	1-4
Sleep Quality[a]	Single item; 1x/day	3.64	0.85	1-5
Subjective Physical Health[a]	3 Subjective Health items; 1x/day	3.36	0.78	1-5
Life Space[b]	Daily Maximum	3.86	1.02	1-5
Social Activity	Hours/Day	3.43	2.66	1-10.50
Physical Activity	Hours/Day	2.09	2.54	1-16
Objective Health[c]	10 Objective Health items; 1x/week	2.45	0.53	1-3

a: 1 = not at all, 3 = moderately, 5 = extremely
b: 1 = been to other rooms of your home, 2 = been to an area outside your home, 3 = been to places in your neighborhood, 4 = been to places outside your neighborhood, 5 = been to places outside your town
c: 1 = limited a lot, 2 = limited a little, 3 = not limited at all

The data in the results that follow were analyzed using multilevel models (MLM) (Bryk & Raudenbush, 1992; Carstensen et al., 2011; Hox, 1998; Mccrae et al., 2008; Singer, 1998), which takes into account the complete dataset rather than just complete cases, allowing the total observed variance in the dependent measure to be partitioned into within-group variance (Level 1) and between-group variance (Level 2), where the “group” is one person’s survey responses per assessment occasion (or day). Thus, this method was suited to nested data (i.e., response occasions or days nested within-persons), a for analysis of daily repeated measures because it does not rely on the assumption of independent observations that standard regression does (Wang, Hamaker, & Bergeman, 2012). Models were run using the PROC MIXED statement in SAS and implementing the COVTEST option, which produces hypothesis tests for the variance and covariance components (Singer, 1998).

PA and NA were treated as separate dependent variables in the results that follow, because they have been found to be differentiable aspects of emotions that operate largely independent of each other (Cacioppo, Gardner, & Berntson, 1999), so I hypothesized that they might be differently predicted by the independent variables of interest. Furthermore, because this study was somewhat exploratory, I was interested first in what the relationship these predictor variables had in isolation with affect when comparing fixed effects models (where predictors’ coefficients represented the overall within-person relationships with the outcome) and random effects models (where coefficients were estimates of the between-person variability around the within-person relationships), and second, what model was most parsimonious after controlling for the other variables. Individuals were assumed to have different mean PA and NA scores overall, so intercepts were treated as random for all models. An unstructured covariance matrix was specified, which is common in nested designs and allows the fixed and random parameter estimates to be determined by the data (Singer, 1998). Random estimates can only be obtained for Level 1 variables, so unless indicated otherwise, 3x per day variables (e.g., affect, stress, pain) were averaged by day to enable us to investigate factors that were only asked once per day (e.g., social activity, physical activity) at Level 1, with the resulting multilevel structure being 20 (days) within 59 (persons).

In multilevel modeling, the first step is to run a null model (also referred to as the unconditional model) with no predictors, to determine if there is a significant amount of variability to be explained and if so, how much exists at each level (Nezlek, 2001; Raudenbush & Bryk, 2002). In the following equation for the null model, Y is the outcome variable (PA or NA) and is a function of β_0, a term which estimates the intercept of the overall model fitted to the data (γ_{00}) and the variability of intercepts around that overall model (μ_{0j}) and r, the error:

Level 1: $Y_{ij} = \beta_{0j} + r_{ij}$
Level 2: $\beta_{0j} = \gamma_{00} + \mu_{0j}$

To determine whether the source of variance is level 1 or level 2, an intraclass correlation coefficient (ICC) is calculated using the following formula, where ρ is the proportion of variability that is between-persons and 1- ρ is the proportion of variability that is within-persons: $\rho = \tau_{00} / (\tau_{00} + \sigma^2)$

The ICC was calculated for each model that had a different outcome variable. Thus, two unconditional models were estimated, one for PA and another for NA.

Positive Affect – Daily Aggregate Models

How much variability (between- and within-persons) was observed in Positive Affect?

Results from analysis of the null model indicated that the grand mean for Positive Affect was 3.11 and that 78% of the variance in daily PA was between-persons ($\tau_{00} =$ 0.37, z = 5.31, p

<.001) and 22% was within-persons (σ^2 = .10, z = 23.61, p < .001) (See Figure 4). Thus, there was sufficient within-person variability to justify further analyses.

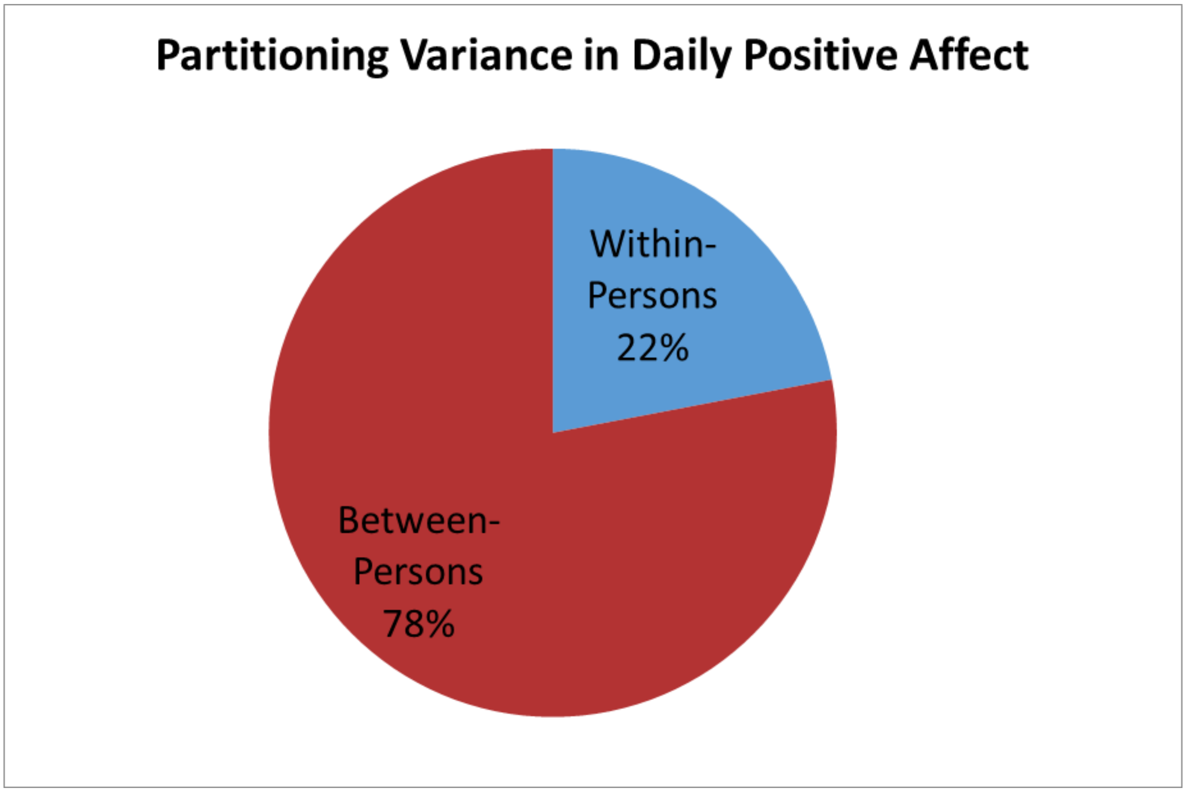

Figure 4. Partitioned Positive Affect Variance in Daily Models

Was Positive Affect IIV predicted by short-term daily factors?

To determine if Positive Affect variability was predicted by short-term daily factors, these predictors were added to the models first as fixed coefficients only, and then allowing random coefficients to determine if model fit was better for these models (individual differences in the relationship between the predictor and Positive Affect). Except for Objective Health, all predictor variables were centered within-cluster (also referred to as group-mean centering), where one "cluster" is all of the data from one individual. Centering within-cluster (each person's mean for a given variable is subtracted from each of their own individual scores for that variable) can only be done with Level 1 predictors because it eliminates any Level 2 (between-person) influences on the parameter estimates that are due to differences in mean scores on that variable (Field, 2013; Raudenbush & Bryk, 2002). This adjusts the intercepts for differences in the predictor across units of analysis and as a result, the parameter estimates are pure indications of within-person relationships with affect, and the intercept can be interpreted as the predicted PA score when every person is at their own mean of a given predictor variable (Enders & Tofighi, 2007; Field, 2013; Raudenbush & Bryk, 2002). This is the recommended centering method when level 1 predictors are of primary interest (Enders & Tofighi, 2007) as was the case in this research study. The equation for the fixed slope coefficients models was:

Level 1: $PA_{ij} = \beta_{0j} + \beta_1(X_{ij} - X_{.j}) + r_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + \mu_{0j}$

$\beta_{1j} = \gamma_{10}$

Where a given person's (j) PA score at a given observation (i) is a function of:

- β_{0j}: Which was broken down into the intercept and the intercept variance
  - γ_{00}: the mean PA score when person j is at their own mean for a given predictor X (intercept)
  - μ_{0j}: the extent to which a person varied from their own PA mean (intercept variance)
- $\beta_1(X_{ij} - X_{.j})$: The slope of the model
  - γ_{10}: the within-person relationship between group-mean centered predictor X and PA
- r_{ij}: Residual Level 1 variance after accounting for X

The equation for the random slope coefficients models is similar but with an additional parameter, the slope variance (μ_{1i}), which is an estimate of the between-person variance in the group-mean centered predictor-PA slope:

$$\text{Level 1: } PA_{ij} = \beta_{0j} + \beta_{1j}(X_{ij} - X_{.j}) + r_{ij}$$
$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{1j} = \gamma_{10} + \mu_{1i}$$

Model fit was determined using the difference in the -2 Residual Log Likelihood ratios for the fixed coefficient and random coefficient models as the test value in a Chi square distribution with 2 degrees of freedom (the difference in the number of random effects between the models) (Singer, 1998).

Daily Pain

For the fixed effects model, daily pain significantly predicted positive affect (γ_{10} = -.09, *t* = -3.83, p < .001). Overall, on days when people reported greater physical pain, their PA was lower, such that for every 1 unit increase in pain, PA decreased by .09 units.

For the random effects model, the overall within-person relationship between daily pain and positive affect remained. However, there was significant slope variance (τ_{11} = .04, *t*=2.71, p=.003), indicating that there were between-person differences in within-person pain-PA relationships such that although the average within-person relationship was negative, for some people it may have been positive or may not have existed at all. Additionally, 8% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between daily pain and positive affect constrained to be equal across persons (X^2 (2) = 43.4, p <.05). See Figure 5.

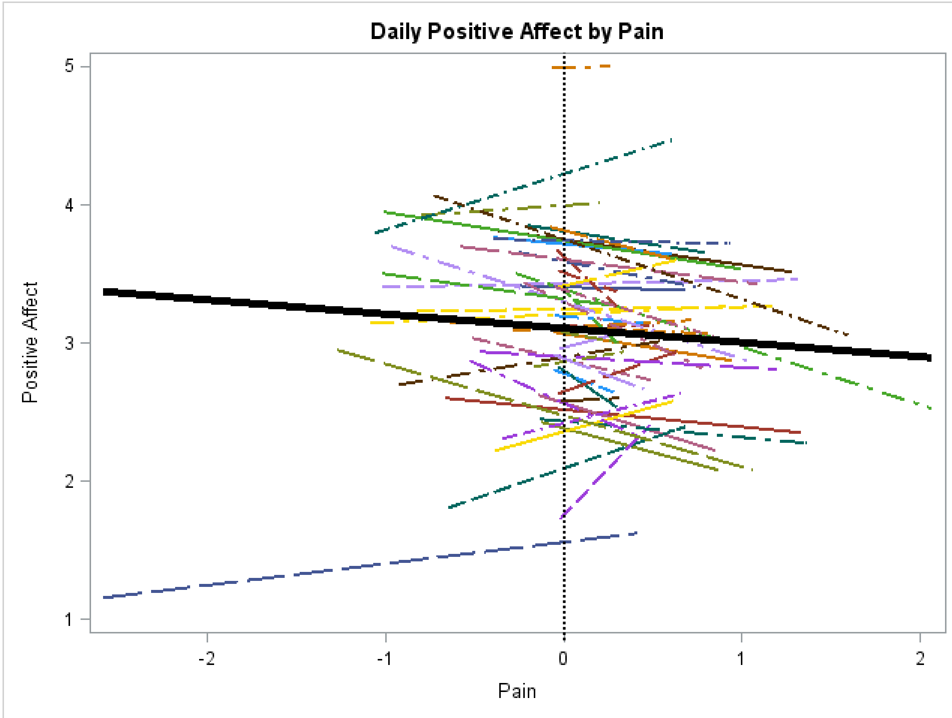

Figure 5. Daily positive affect predicted by daily pain with pain centered within-person. The thick black line represents the grand relationship (fixed effect) between pain and positive affect, which was negative. Each of the 59 colored lines represents a different individual's pain-positive affect relationship and because pain is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of pain. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) are statistically different from each other overall. The slope-intercept variance was not significant, so although there were individual differences in pain-positive affect relationships, the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of pain.

Daily Stress

For the fixed effects model, daily stress significantly predicted PA (γ_{10} = -.06, t = -1.99, p = .047). Overall, on days when people reported greater daily stress, their PA was lower, such that for every 1 unit increase in stress, PA decreased by .06 units.

For the random effects model, however, there was no longer a significant overall within-person relationship between daily stress and positive affect but there *was* significant slope variance (τ_{11} = .03, *t*=2.10, p=.017), indicating that there were between-person differences in within-person stress-PA relationships such that some people might have had a significant (positive or negative) daily stress-PA relationship, but overall there was no grand within-person relationship. Additionally, 4% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between daily stress and positive affect constrained to be equal across persons (X^2 (2) = 17.5, p <.05). See Figure 6.

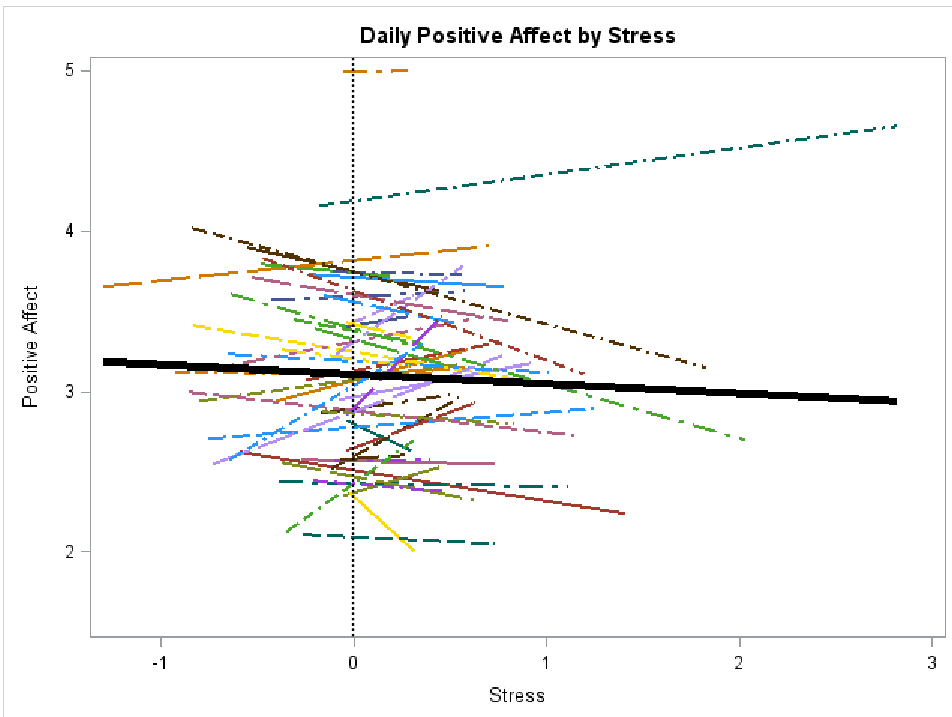

Figure 6. Daily positive affect predicted by daily stress with stress centered within-person. The thick black line represents the grand relationship (fixed effect) between stress and positive affect, which was non-significant when allowing random slopes. Each of the 59 colored lines represents a different individual's stress-positive affect relationship and because stress is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of stress. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) are statistically different from each other overall. The slope-intercept variance was not significant, so although there were individual differences in stress-positive affect relationships, the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of stress.

Sleep Quality

For the fixed effects model, sleep quality (on the previous night) significantly predicted PA (γ_{10} = .07, t = 4.44, $p < .001$). Overall, on days when people reported greater sleep quality the night before their PA was higher, such that for every 1 unit increase in sleep quality, PA increased by .07 units.

For the random effects model, the overall within-person relationship between sleep quality and positive affect remained. However, there was significant slope variance (τ_{11} = .01, t=2.00, p=.023), indicating that there were between-person differences in within-person sleep-PA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 7% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between sleep quality and positive affect constrained to be equal across persons (X^2 (2) = 8.5, $p <.05$). See Figure 7.

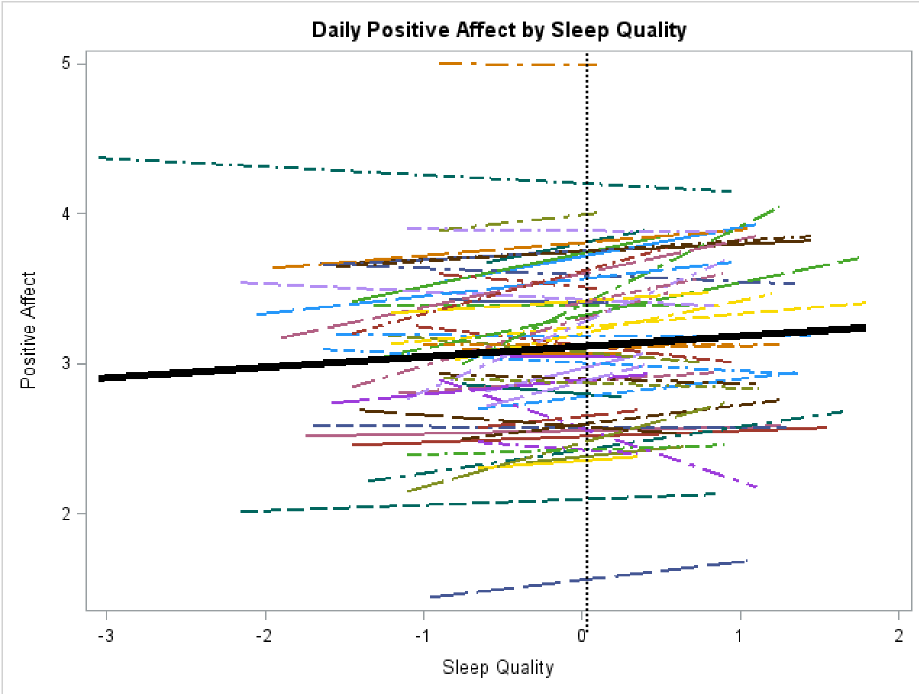

Figure 7. Daily positive affect predicted by daily sleep quality with sleep quality centered within-person. The thick black line represents the grand relationship (fixed effect) between sleep quality and positive affect, which was positive. Each of the 59 colored lines represents a different individual's sleep quality-positive affect relationship and because sleep quality is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of sleep quality. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) are statistically different from each other overall. The slope-intercept variance was not significant, so although there were individual differences in sleep quality-positive affect relationships, the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of sleep quality.

Subjective Physical Health

For the fixed effects model, subjective health significantly predicted PA(γ_{10} = .27, t = 11.53, $p < .001$). Overall, on days when people reported greater subjective health their PA was higher, such that for every 1 unit increase in subjective health, PA increased by .27 units.

For the random effects model, the overall within-person relationship between subjective health and positive affect remained. However, there was significant slope variance (τ_{11} = .02, t=1.98, p=.024), indicating that there were between-person differences in within-person subjective health-PA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 15% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between subjective health and positive affect constrained to be equal across persons (X^2 (2) = 11.2, p <.05). See Figure 8.

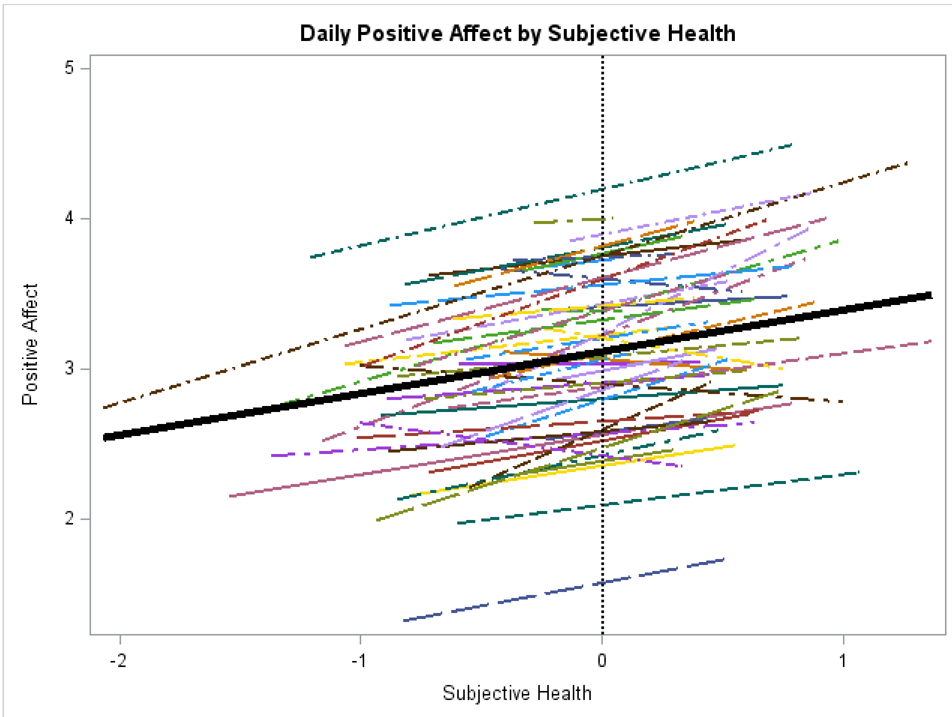

Figure 8. Daily positive affect predicted by daily subjective health with subjective health centered within-person. The thick black line represents the grand relationship (fixed effect) between subjective health and positive affect, which was positive. Each of the 59 colored lines represents a different individual's subjective health-positive affect relationship and because subjective health is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of subjective health. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) are statistically different from each other overall. The slope-intercept variance was not significant, so although there were individual differences in subjective health-positive affect relationships, the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of subjective health.

Life space

For the fixed effects model, life space significantly predicted PA (γ_{10} = .03, *t* = 3.06, p = .002). Overall, on days when people traveled greater distances from their bedrooms than their average their PA was higher, such that for every 1 unit increase in life space, PA increased by .03 units.

For the random effects model, however, there was no longer a significant overall within-person relationship between life space and positive affect but there *was* significant slope variance (τ_{11} = .01, *t*=2.60, p=.005), indicating that there were between-person differences in within-person life space-PA relationships such that some people might have had a significant (positive or negative) daily life space-PA relationship, but overall there was no grand within-person relationship. Additionally, 11% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between life space and positive affect constrained to be equal across persons (X^2 (2) = 25.9, p <.05). See Figure 9.

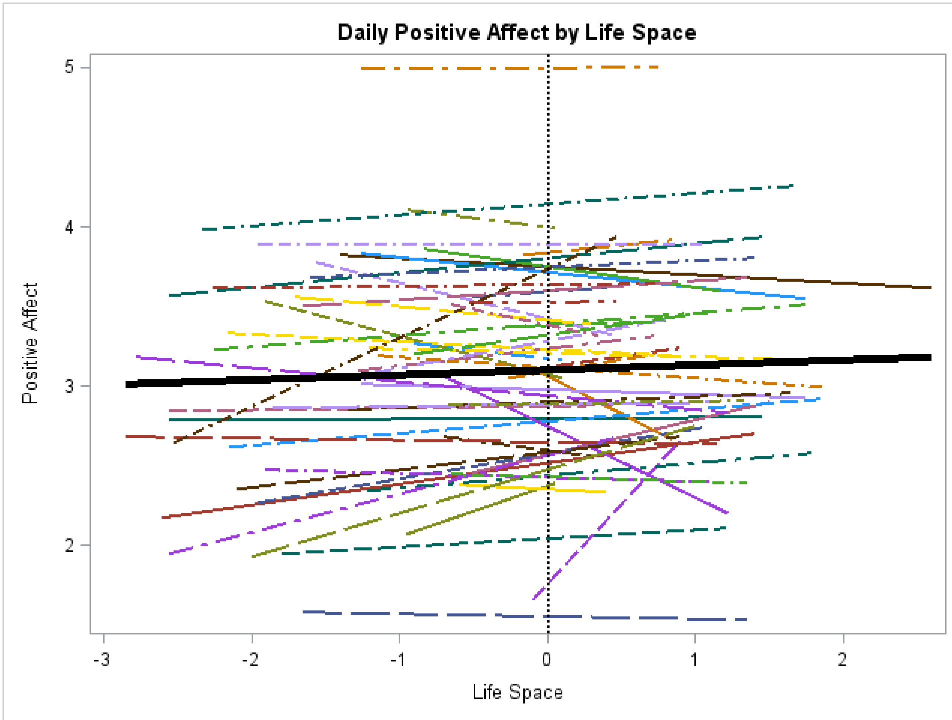

Figure 9. Daily positive affect predicted by daily life space with life space centered within-person. The thick black line represents the grand relationship (fixed effect) between life space and positive affect, which was non-significant when allowing random slopes. Each of the 59 colored lines represents a different individual's life space-positive affect relationship and because life space is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of life space. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) are statistically different from each other overall. The slope-intercept variance was not significant, so although there were individual differences in life space-positive affect relationships, the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of life space.

Physical Activity

For the fixed effects model, physical activity did not significantly predict PA (γ_{10} = .01, t = 0.69, p = .48). Overall, the number of hours that people reported being physically active on a given day did not relate to their PA on that day.

There were also no significant parameters in the random effects physical activity model, suggesting that in addition to there being no overall within-person relationship between physical activity and PA, there were no between-person differences in within-person physical activity-PA slopes. See Figure 10.

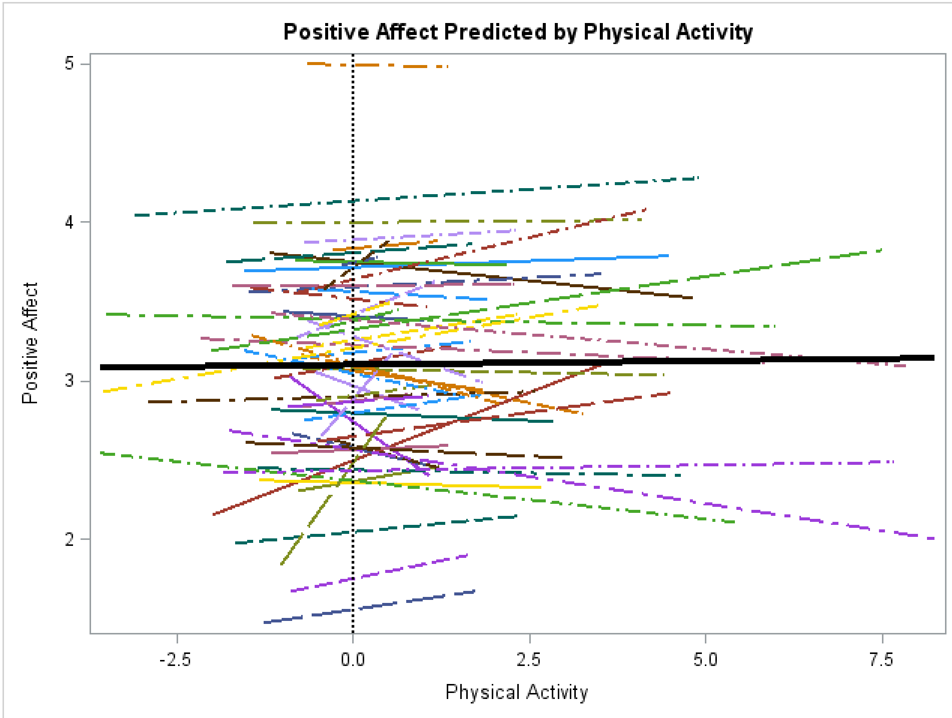

Figure 10. Daily positive affect predicted by daily physical activity with physical activity centered within-person. The thick black line represents the grand relationship (fixed effect) between physical activity and positive affect, which was non-significant. Each of the 59 colored lines represents a different individual's physical activity-positive affect relationship and because physical activity is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of physical activity. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of physical activity.

<u>Social Activity</u>

For the fixed effects model, social activity did not significantly predict PA (γ_{10} = .01, t = 1.11, p = .27). Overall, the number of hours that people reported being socially active on a given day did not relate to their PA on that day.

There were also no significant parameters in the random effects social activity model, suggesting that in addition to there being no overall within-person relationship between social activity and PA, there were no between-person differences in within-person social activity-PA slopes. See Figure 11.

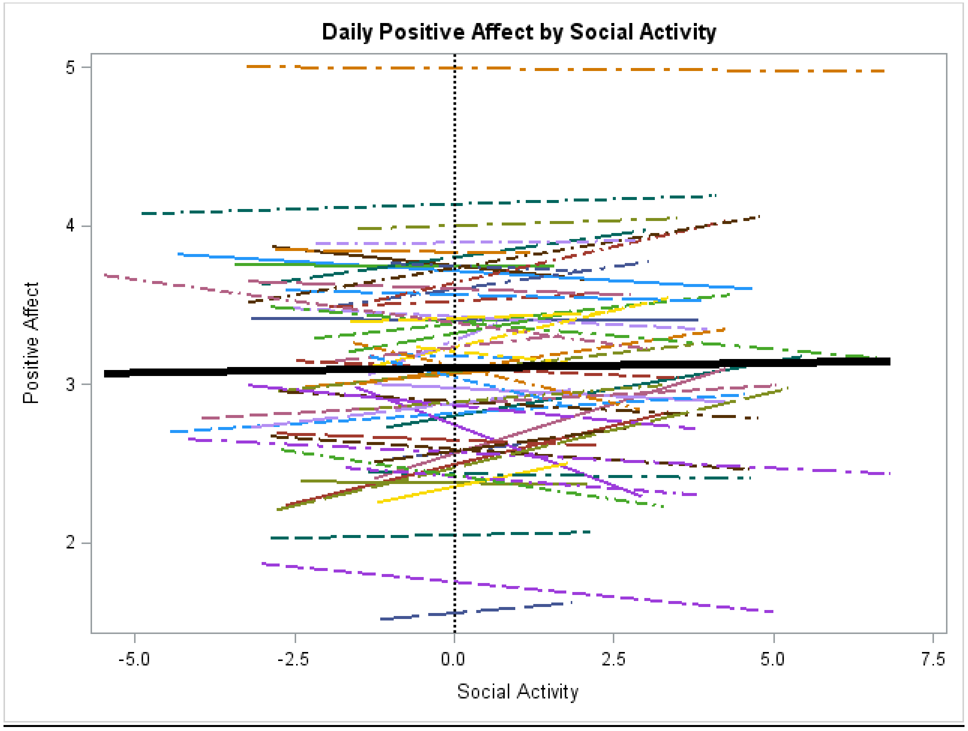

Figure 11. Daily positive affect predicted by daily social activity with social activity centered within-person. The thick black line represents the grand relationship (fixed effect) between social activity and positive affect, which was non-significant. Each of the 59 colored lines represents a different individual's social activity-positive affect relationship and because social activity is centered within-person, where the lines intersect with the vertical dotted line represents that person's positive affect when they are at their mean level of social activity. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of social activity.

Full Models – Fixed and Random

In addition to investigating short-term predictors of PA IIV in isolation, I wanted to determine what relationships persisted and emerged after controlling for the effects of all the other variables[1]. That is, which predictors were significant *unique* predictors of PA IIV. For the fixed effects model, the only significant unique predictors of PA were Subjective Health (γ_{40} = .27, t = 10.71, p <.001) and Life Space (γ_{70} = .04, t= 3.51, p <.001), controlling for Daily Pain, Daily Stress, Sleep Quality, Social Activity, Physical Activity, and Objective Health. The intercept estimate for this model was 2.81, meaning that if everyone was at their mean for all of these variables, PA would be expected to be 2.81. For every one unit increase in Subjective Health, a .27 unit increase in PA would be expected. For every one unit increase in Life Space, a .04 unit increase in PA would be expected. This model explained 20% of the within-person variance in Positive Affect.

For the random effects model, slopes were allowed to vary for all variables except for physical and social activity because the model would not converge with them included. Convergence issues can be indicative of model misspecification, and occur more frequently as more parameters are added to a model. Indeed, when the full model was run with *only* Physical and Social Activity allowed to vary randomly none of the random effects were significant, so omitting them as random effects in the final model likely did not impact the within-person variance accounted for. In the final model, Subjective Health and Life Space remained the only significant unique predictors of within-person PA. However, there were also significant random

[1] A centered "Day" variable was initially entered as a fixed effect to the full models (i.e. the middle of the study, day 10.5, coded as 0) to explore temporal trends. Doing so did not impact the significance of any fixed or random effects in the full model. It is possible that "Day" have random slope variance associated with affect (such that there were individual differences in how people's emotions changed over the course of the study). However, it was not included in any analyses as it was not a primary variable of interest and restricted the number of random predictors (that *were* primary variables of interest) that would converge in the models run.

effects, indicating between-person differences in the within-person relationships. There was significant slope variance in Daily Pain (τ_{11} = .02, t=2.04, p=.021), Daily Stress (τ_{22} = .03, t=1.85, p=.032), and Life Space (τ_{55} = .01, t=1.78, p=.037) indicating that there were between-person differences in the within-person relationships such that some people's PA may have increased while others' decreased in response to increases in these variables. For Pain and Stress, this was in spite of their having no overall within-person relationship with PA. This model explained 32% of the within-person variance in PA, and allowing slopes to vary resulted in a better fit than the model with the slopes constrained to be equal across persons (X^2 (10) = 81, $p < .05$). See Table 4 for an overview of the isolated models and full random model.

Post-hoc analyses were conducted to attempt to account for the significant slope variances by including cross-level interactions between the person level (Level 2) means with their corresponding day level (Level 1) for those predictors that showed significant slope variances in the full random model (Stress, Pain, and Life Space). Level 1 Stress*Level 2 Stress, Level 1 Pain*Level 2 Pain, and Level 1 Life Space*Level 2 Life Space were added to the full random NA model described in the previous paragraph. None of these interactions were significant, and the Stress, Pain, and Life Space slope variances all remained significant, indicating that the individual differences in these predictor-PA slopes could not be explained by the person level means of these predictors.

Beyond attempting to understand if the random effects of these Level 1 predictors were accounted for by their Level 2 counterparts (which they were not), I also explored the possibility of cross-level interactions between different Level 2-Level 1 predictors accounting for Level 1 slope variance effects. To do this, I added interactions of every Level 2 predictor with the Level 1 predictors showing significant slope variance to the random model one at a time (with the

Stress, Pain, and Life Space cross-level interactions still included). For example, did between-person differences in mean Stress (for the entire study) account for the variance in Level 1 Pain-PA slopes that was observed? In this example, the predictor would be a Level 1 Pain*Level 2 Stress interaction. None of these interactions were significant, and the Stress, Pain, and Subjective Health slope variances all remained significant. This indicated that the between-person differences in mean levels of Pain, Stress, Sleep Quality, Subjective Health, Physical Activity, Social Activity, and Life Space could not account for the random effects of Pain, Stress, or Subjective Health on Positive Affect. Because inclusion of these interactions did not impact the observed random effects, only the results of the original full random model will be reported and will serve as the focus of the discussion[2].

[2] Inclusion of the Level 2 means and Level 1*Level 2 interactions did have an impact on the fixed effects such that Level 2 Subjective Health was a significant unique fixed predictor of PA, and Level 1 Life Space was no longer a significant unique fixed predictor of PA. However, because the focus of this thesis was on within-person (Level 1) variance, these effects will not be interpreted in this paper but will serve as the basis for further analysis of this dataset.

Table 3. *Positive Affect Daily Aggregate Model Summaries*

Sig. Effects **Predictor**	Fixed	Slope Variance	Slope-Intercept Covariance	Best Fitting Model	% Within-Person Explained
Subjective Health	X	X		Random	15%
Life Space	X	X		Random	11%
Pain	X	X		Random	8%
Sleep Quality	X	X		Random	7%
Physical Activity				Fixed	5%
Social Activity				Fixed	5%
Stress		X		Random	4%
Full Model	• Subjective Health • Life Space	• Pain • Stress • Life Space		Random	32%

Negative Affect – Daily Aggregate Models

How much variability (between- and within-persons) exists in Negative Affect?

A Kolmogorov-Smirnov test of normality revealed significant positive skew in NA. Thus, statistical outliers (*M*=1.15 +/- 2 SD) were removed from analysis. Additionally, a Log10 transformation was applied to the daily NA scores. After skew correction, the same procedure was used for the following NA models as was used in the PA models, in which an unconditional model was analyzed and variance was partitioned into between and within-persons (Nezlek, 2001; Raudenbush & Bryk, 2002). Results from the analysis of the null model indicated that 66% of the variance in daily NA was between-persons ($\tau_{00} =$ .002, z = 5.18, p =.004) and 34% was within-persons (σ^2 = .001, z = 23.11, p < .001) (See Figure 12). Thus, there was sufficient within-person variability to justify further analyses.

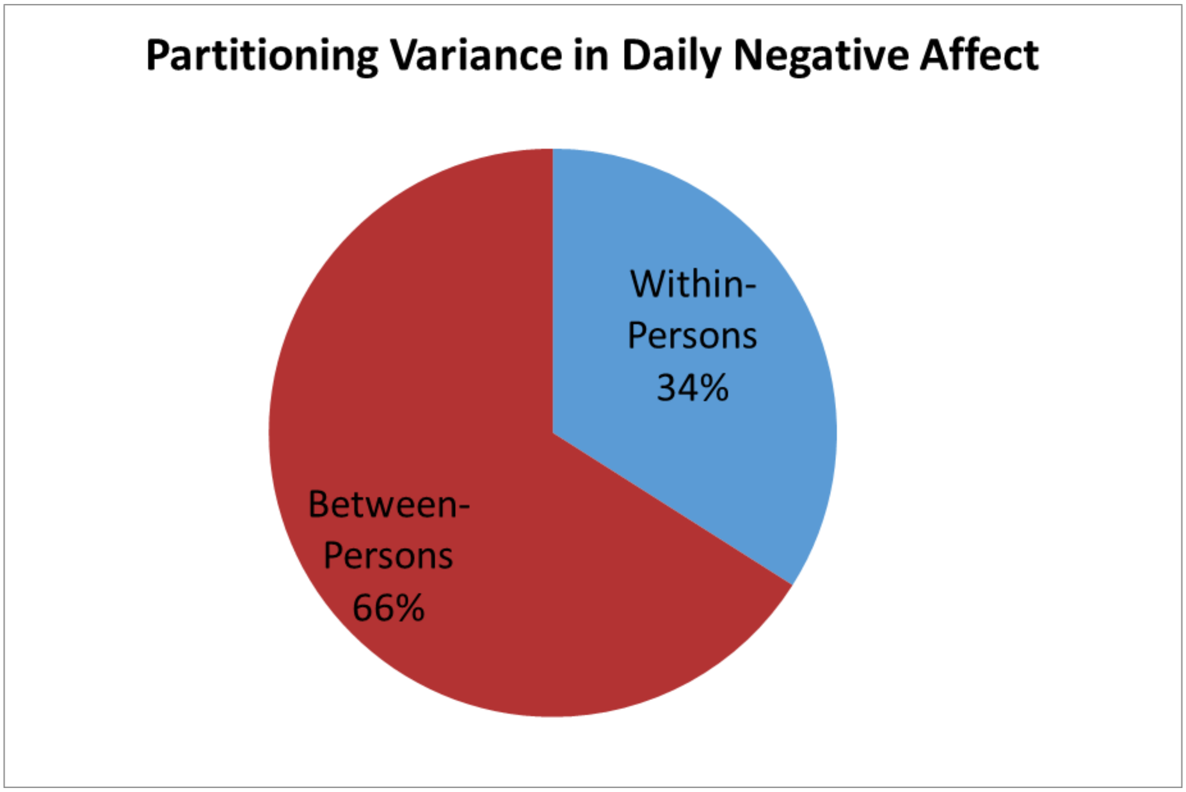

Figure 12. Partitioned Negative Affect Variance in Daily Models

Was Negative Affect IIV predicted by short-term daily factors?

The same analysis, centering procedures, and equations as used in Positive Affect (except with Negative Affect as the outcome variable) were used to determine if Negative Affect variability was predicted by short-term daily factors, with these predictors added to the models first as fixed effects only, and then allowing random effects to determine if model fit was better for these models (allowing individual differences in the relationship between the predictor and Negative Affect).

Daily Pain

For the fixed effects model, daily pain significantly predicted NA (γ_{10} = .008, t = 2.98, p=.003). Overall, on days when people reported greater pain, their NA was higher.

For the random effects model, the overall within-person relationship between daily pain and negative affect remained. There was also significant slope variance (τ_{11} = .001, *t*=1.67, p=.047), indicating that there were between-person differences in within-person pain-NA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 3% of the within-person variance in NA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between pain and negative affect constrained to be equal across persons (X^2 (2) = 6.6, $p < .05$). See Figure 13.

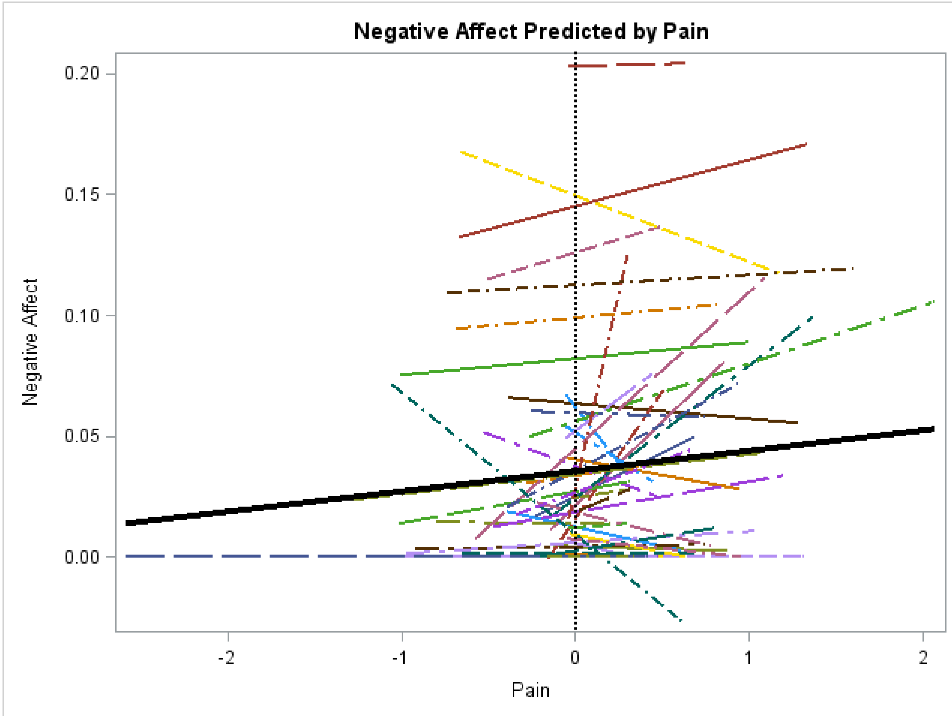

Figure 13. Daily negative affect predicted by daily pain with pain centered within-person. The thick black line represents the grand relationship (fixed effect) between pain and negative affect, which was non-significant. Each of the 59 colored lines represents a different individual's pain-negative affect relationship and because pain is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they were at their mean level of pain. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) were statistically different from each other overall. The slope-intercept variance was not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of pain.

Daily Stress

For the fixed effects model, daily stress significantly predicted NA (γ_{10} = .058, t = 19.42, p < .001). Overall, on days when people reported higher stress, their NA was higher.

For the random effects model, the overall within-person relationship between daily stress and negative affect remained. There was also significant slope variance (τ_{11} = .001, t=2.86, p=.002), indicating that there were between-person differences in within-person pain-NA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 32% of the within-person variance in NA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between stress and negative affect constrained to be equal across persons (X^2 (2) = 42.2, p <.05). See Figure 14.

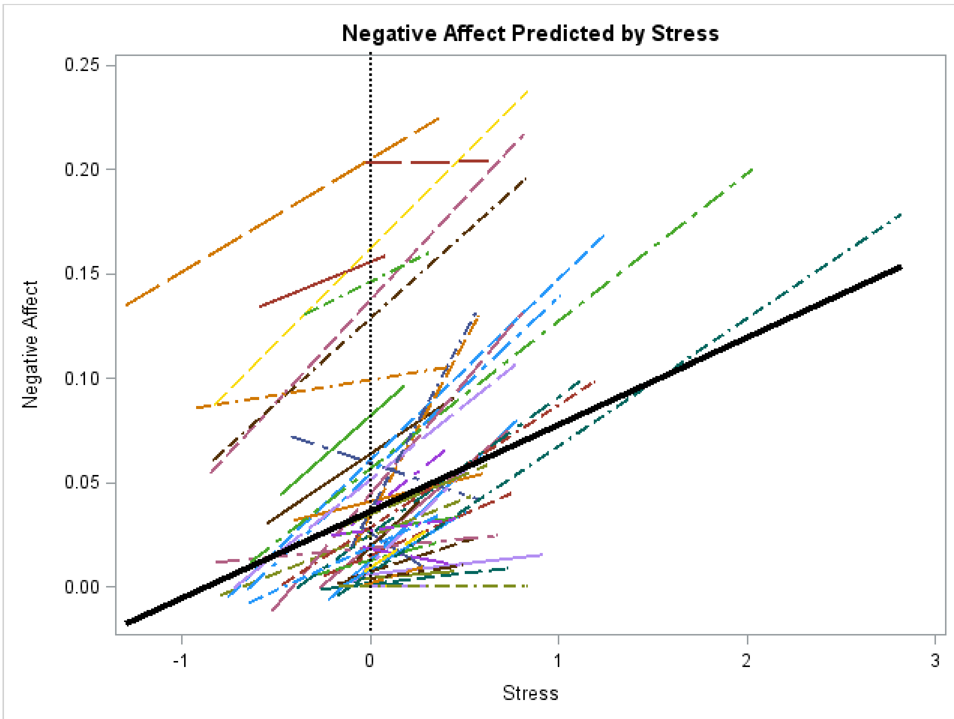

Figure 14. Daily negative affect predicted by daily stress with stress centered within-person. The thick black line represents the grand relationship (fixed effect) between stress and negative affect, which was non-significant. Each of the 59 colored lines represents a different individual's stress-negative affect relationship and because stress is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they are at their mean level of stress. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) were statistically different from each other. The slope-intercept variance was not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of stress.

Sleep Quality

For the fixed effects model, sleep quality did not significantly predict NA (γ_{10} = -.003, t = -1.86, p=.063). Overall, the quality of sleep a person reported from the night before did not relate to their NA on that day.

There were also no significant parameters in the random slopes sleep model, suggesting that in addition to there being no overall within-person relationship between sleep and PA, there were no between-person differences in within-person sleep-NA slopes. Allowing slopes to vary did not result in a better fit than the model with the slope between sleep and negative affect constrained to be equal across persons. See Figure 15.

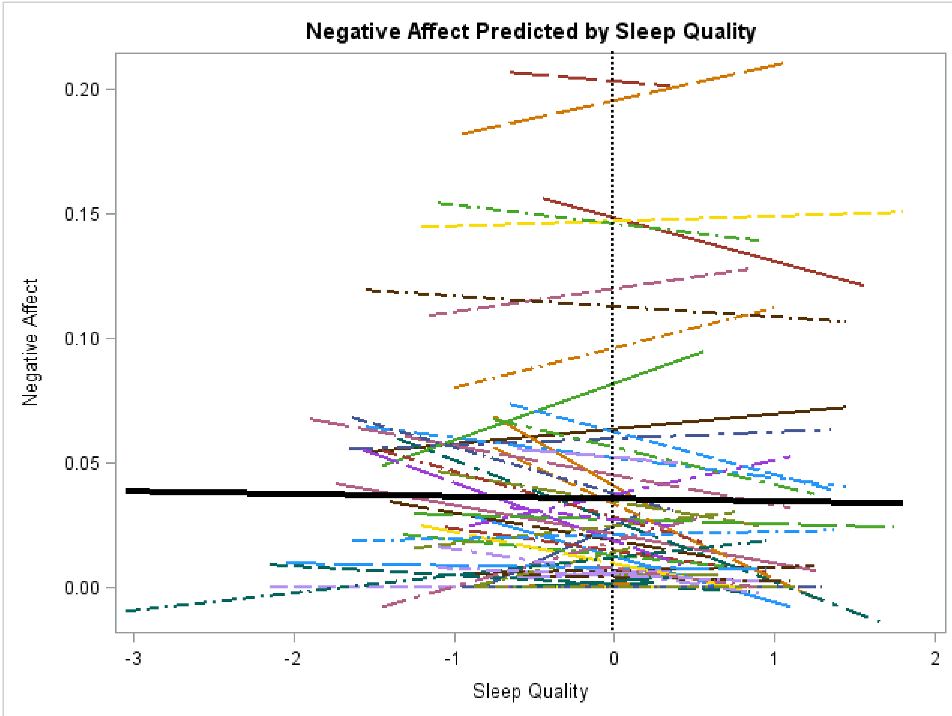

Figure 15. Daily negative affect predicted by daily sleep quality with sleep quality centered within-person. The thick black line represents the grand relationship (fixed effect) between sleep and positive affect, which was non-significant. Each of the 59 colored lines represents a different individual's sleep quality-negative affect relationship and because sleep quality is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they are at their mean level of sleep quality. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of sleep quality.

<u>Subjective Health</u>

For the fixed effects model, subjective health significantly predicted NA (γ_{10} = -.01, t = -3.23, p =.001). Overall, on days when people reported greater subjective health, their NA was lower.

For the random effects model, the overall within-person relationship between subjective health and NA remained. However, there was significant subjective health slope-variance (τ_{10} = .001, t=2.00, p= .023), indicating that there were between-person differences in within-person subjective health-NA relationships such that although the average within-person relationship was negative, for some people it may have been positive or may not have existed at all. Additionally, 11% of the within-person variance in NA was accounted for by the model where subjective health-NA slopes were allowed to vary and this model was a significantly better fit than the fixed effects model (X^2 (2) = 10.5, p <.05). See Figure 16.

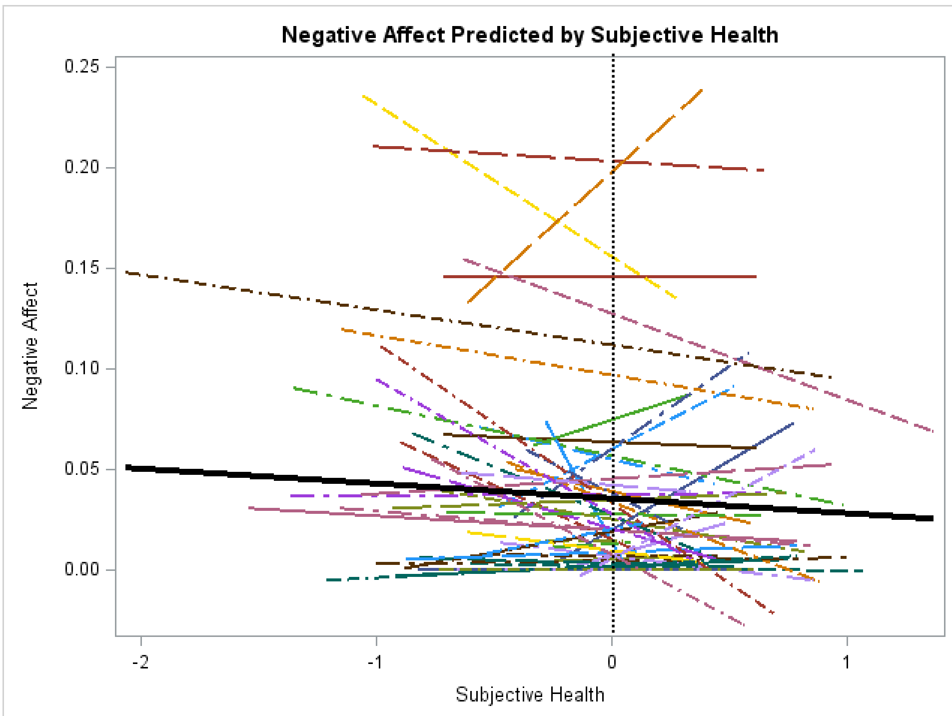

Figure 16. Daily negative affect predicted by subjective health with subjective health centered within-person. The thick black line represents the grand relationship (fixed effect) between subjective health and negative affect, which was negative. Each of the 59 colored lines represents a different individual's subjective health-negative affect relationship and because subjective health is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they are at their mean level of subjective health. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was significant, so the slopes of the colored lines (individuals) were statistically different from each other overall. The slope-intercept variance was not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of subjective health.

Life Space

For the fixed effects model, life space did not significantly predict NA (γ_{10} = -.003, *t* = -1.86, p=.063). Overall, travelling greater distances from their bedrooms on a given day did not significantly influence participants' NA.

There were also no significant parameters in the random slopes life space model, suggesting that in addition to there being no overall within-person relationship between life space and NA, there were no between-person differences in within-person life space-NA slopes. Allowing slopes to vary did not result in a better fit than the model with the slope between life space and negative affect constrained to be equal across persons. See Figure 17.

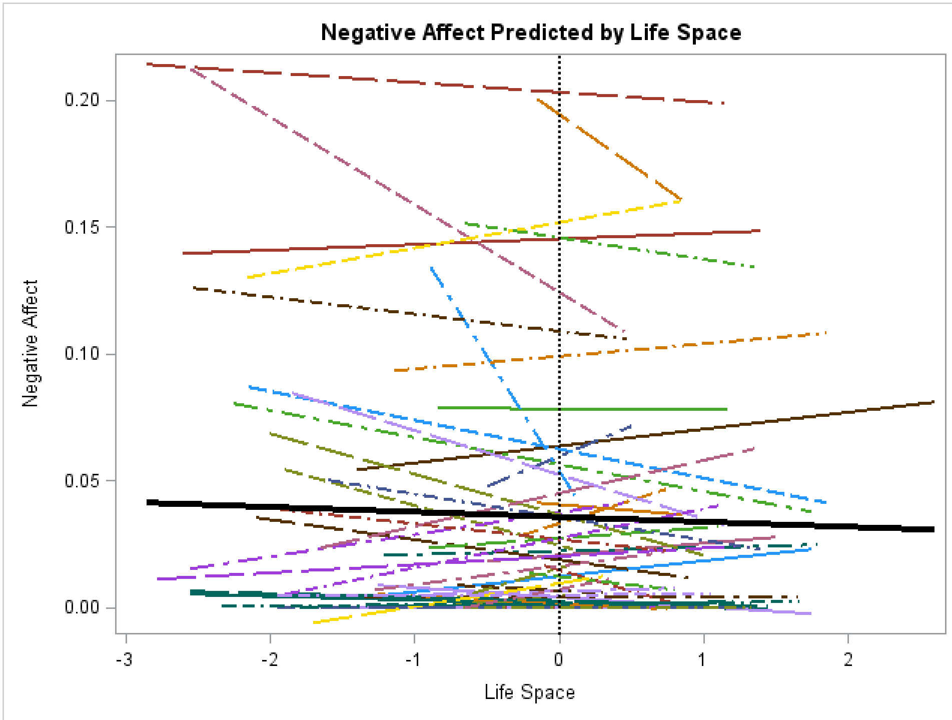

Figure 17. Daily negative affect predicted by life space with life space centered within-person. The thick black line represents the grand relationship (fixed effect) between life space and negative affect, which was non-significant. Each of the 59 colored lines represents a different individual's life space-negative affect relationship and because life space is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they are at their mean level of life space. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of life space.

Physical Activity

For the fixed effects model, physical activity did not significantly predict NA (γ_{10} = -.0007, *t* = -.05, p=.405). Overall, the number of hours a person spent engaging in physical activity did not relate to their NA on that day.

There were also no significant parameters in the random effects Physical Activity model, suggesting that in addition to there being no overall within-person relationship between physical activity and NA, there were no between-person differences in within-person physical activity-

NA slopes. Allowing slopes to vary did not result in a better fit than the model with the slope between physical activity and negative affect constrained to be equal across persons. See Figure 18.

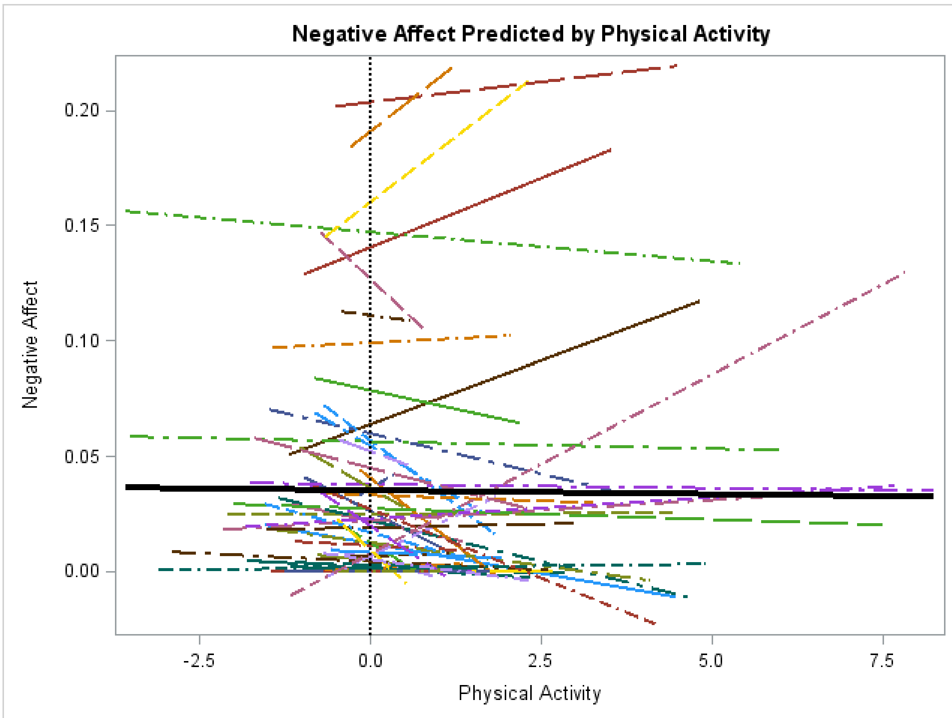

Figure 18. Daily negative affect predicted by daily physical activity with physical activity centered within-person. The thick black line represents the grand relationship (fixed effect) between physical activity and positive affect, which was non-significant. Each of the 59 colored lines represents a different individual's physical activity-negative affect relationship and because physical activity is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative when they are at their mean level of physical activity. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean positive affect (intercept) when they were at their mean level of physical activity.

Social Activity

For the fixed effects model, social activity did not significantly predict NA (γ_{10} = -.0001, *t* = .01, p=.872). Overall, the number of hours a person spent engaging in social activity did not relate to their NA on that day.

There were also no significant parameters in the random effects social activity model, suggesting that in addition to there being no overall within-person relationship between social activity and NA, there were no between-person differences in within-person social activity-NA slopes. Allowing slopes to vary did not result in a better fit than the model with the slope between social activity and negative affect constrained to be equal across persons. See Figure 19.

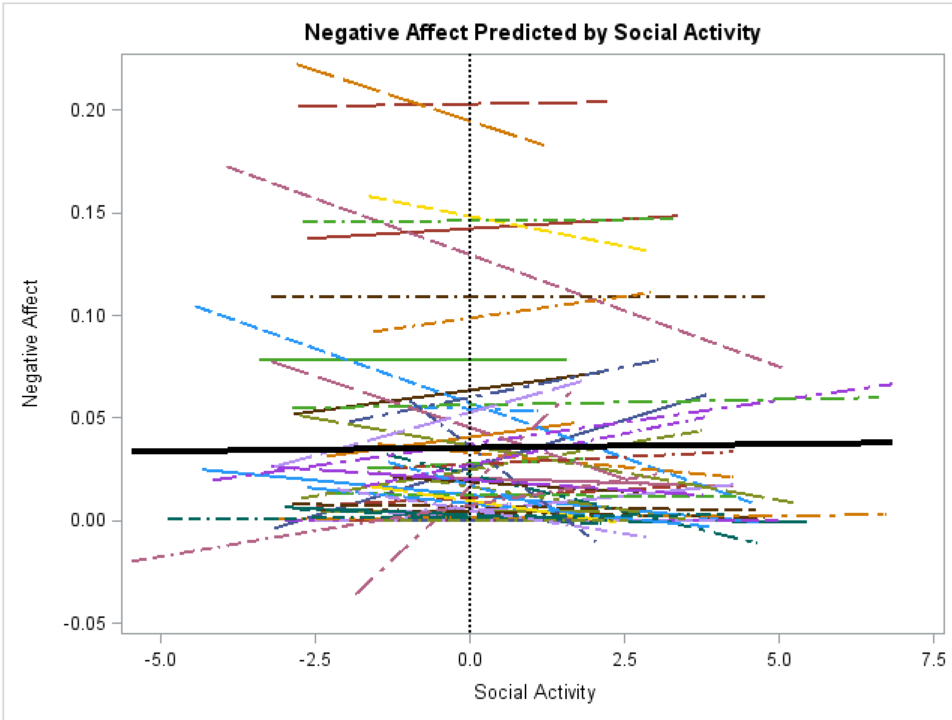

Figure 19. Daily negative affect predicted by social activity with social activity centered within-person. The thick black line represents the grand relationship (fixed effect) between social activity and negative affect, which was non-significant. Each of the 59 colored lines represents a different individual's social activity-negative affect relationship and because social activity is centered within-person, where the lines intersect with the vertical dotted line represents that person's negative affect when they are at their mean level of social activity. There are two potential random effects; slope variance and slope-intercept variance. Here, the slope variance was non-significant, so the slopes of the colored lines (individuals) are not statistically different from each other overall. The slope-intercept variance was also not significant, so the nature of the slopes did not depend on individuals' mean negative affect (intercept) when they were at their mean level of social activity.

Full Models – Fixed and Random

As with Positive Affect IIV, in addition to investigating short-term predictors of Negative Affect IIV in isolation, I wanted to determine what relationships persisted and emerged after controlling for the effects of all the other variables[3]. For the fixed effects model, there were two significant unique predictors of Negative Affect after controlling for Daily Pain, Sleep Quality,

[3] As with the Positive Affect full models, a centered "Day" variable was initially entered as a fixed effect in the Negative Affect full models. Again, doing so did not impact the significance of the fixed or random effects and was subsequently removed from analysis.

Subjective Health, Social Activity, Physical Activity, and Objective Health; namely, Stress (γ_{20} = .06, t = 16.96, p<.001) and Life Space (γ_{80} = -.002, t = -1.97, p=.049). This model explained 29% of the within-person variability in Negative Affect.

For the random effects model, slopes were allowed to vary for all variables except for physical activity and social activity because the model would not converge with them included. When models were run with the omitted predictors included as random components in isolation, there were no significant random effects, indicating that their exclusion as random effects in the full model did not significantly impact the results. In the final random model, Stress was the only significant unique fixed predictor of within-person NA (γ_{20} = .05, t = 7.90, p<.001). Additionally, the slope variances were significant for Pain (τ_{11} = .001, t=2.76, p=.003), Stress (τ_{22} = .001, t=3.00, p=.001), and Subjective Health (τ_{44} = .001, t=2.24, p=.013). For stress, although the average within-person relationship with negative affect was positive, for some people it may have been negative or may not have existed at all. For pain and subjective health, although there was no overall relationship with NA, there were significant between-person differences in the within-person slopes. This model explained 45% of the within-person variance in NA, and allowing slopes to vary resulted in a better fit than the model with the slopes constrained to be equal across persons (X^2 (8) = 99.6, p <.05). See Table 4 for an overview of lone predictor and full models.

As with PA, post-hoc analyses were conducted to attempt to account for the significant slope variances by including cross-level interactions between the person level (Level 2) means with their corresponding day level (Level 1) for those predictors that showed significant slope variances in the full random model (Stress, Pain, and Subjective Health). Level 1 Stress*Level 2 Stress, Level 1 Pain*Level 2 Pain, and Level 1 Subjective Health*Level 2 Subjective Health were added to the full random NA model described in the previous paragraph. None of these interactions were significant, and the Stress, Pain, and Subjective Health slope variances all remained significant, indicating that the individual differences in these predictor-NA slopes could not be explained by the person level means of these predictors.

Again, in an attempt understand if the random effects of these Level 1 predictors were accounted for by their Level 2 counterparts (which they were not), I also explored the possibility of cross-level interactions between different Level 2-Level 1 predictors accounting for Level 1 slope variance effects. To do this, I added interactions of every Level 2 predictor with the Level 1 predictors showing significant slope variance to the random model one at a time (with the Stress, Pain, and Subjective Health cross-level interactions still included). For example, did between-person differences in mean Stress (for the entire study) account for the variance in Level 1 Pain-PA slopes that was observed? In this example, the predictor would be a Level 1 Pain*Level 2 Stress interaction. None of these interactions were significant, and the Stress, Pain, and Subjective Health slope variances all remained significant. This indicated that the between-person differences in mean levels of Pain, Stress, Sleep Quality, Subjective Health, Physical Activity, Social Activity, and Life Space could not account for the random effects of Pain, Stress, or Subjective Health on Negative Affect. Because inclusion of these interactions did not impact the observed random effects, only the results of the original full random model will be reported and will serve as the focus of the discussion[4].

[4] Including the Level 2 means and Level 1*Level 2 interactions did have an impact on the fixed effects. Level 2 Stress and Level 2 Life Space were the only significant unique fixed predictors of NA. Level 1 Stress was no longer a significant unique fixed predictor of NA.

Table 4. *Negative Affect Daily Aggregate Model Summaries*

Sig. Effects **Predictor**	Fixed	Slope Variance	Slope-Intercept Covariance	Best Fitting Model	% Within-Person Explained
Stress	X	X		Random	32%
Subjective Health	X	X		Random	11%
Physical Activity				Fixed	5%
Pain		X		Random	3%
Life Space				Fixed	3%
Social Activity				Fixed	3%
Sleep Quality				Fixed	<1%
Full Model	• Stress	• Pain • Stress • Subjective Health		Random	45%

Are certain factors more predictive of PA or of NA IIV?

The significant unique predictors differed depending on if the outcome was PA or NA (Table 5). The full random slopes model explained 32% of the PA IIV, and 45% of the NA IIV. Additionally, to determine the percentage of within-person variance explained by each individual factor in the full random daily aggregate models, variables were entered in stepwise fashion with residual variances being compared to the unconditional residual to determine the additional % explained in each step (PA: Figure 20, NA: Figure 21). The model-building order was based on the % of within-person variance explained in the isolated variable models described in the previous section, in which each predictor individually modeled PA and NA. See Appendix G for a table of the statistical results of the daily aggregate model tests for PA and NA, Appendix H for the Fixed vs. Random model fit statistics and effect sizes, and Appendix I for a correlation matrix of the primary study variables.

Table 5. *Unique Predictors of Positive Affect vs. Negative Affect Intraindividual Variability*

Positive Affect		Negative Affect	
Fixed	Random	Fixed	Random
• Subjective Health • Life Space	• Pain (Slope) • Stress (Slope) • Life Space (Slope)	• Stress	• Pain (Slope) • Stress (Slope) • Subjective Health (Slope)

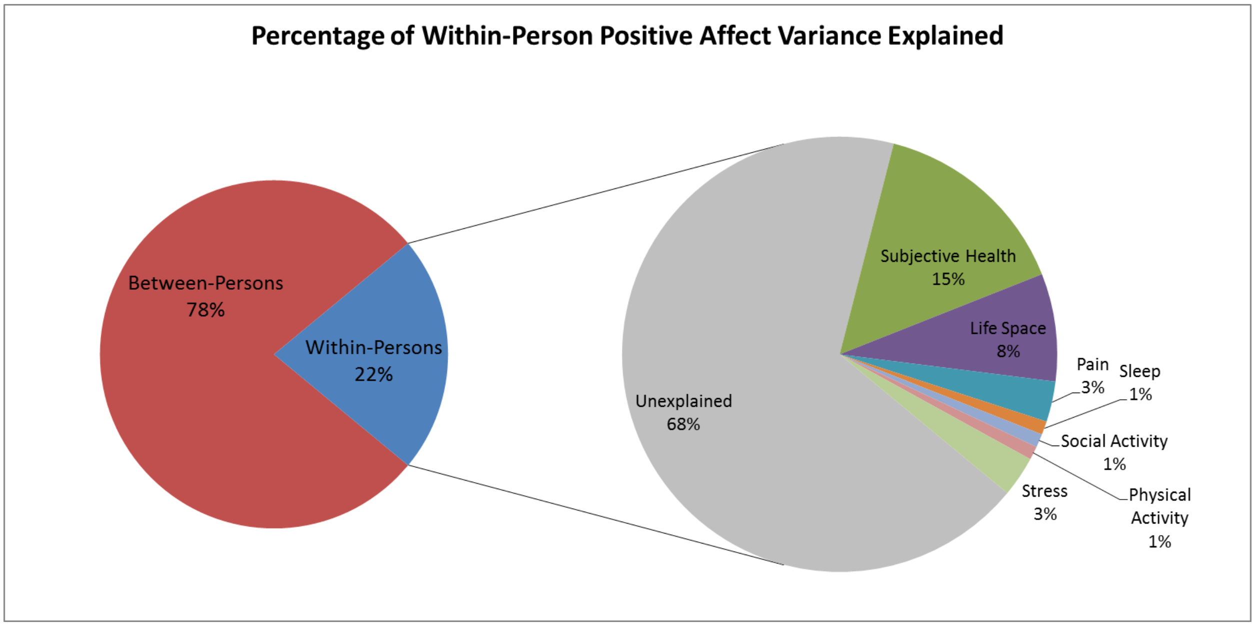

Figure 20. "Exploded" pie chart of the percentage of within-person positive affect variance explained by the predictors. The chart on the left is the total variance in positive affect partitioned into between-persons variance and within-persons variance. The chart on the right is the within-person variance in PA, broken down into the explained (32% total) and unexplained (68%) variance. The explained variance percentages are the variance added (not orthoganol) as each predictor was included in the stepwise models. For PA, the order was Subjective Health, Life Space, Pain, Sleep, Social Activity, Physical Activity, and Stress.

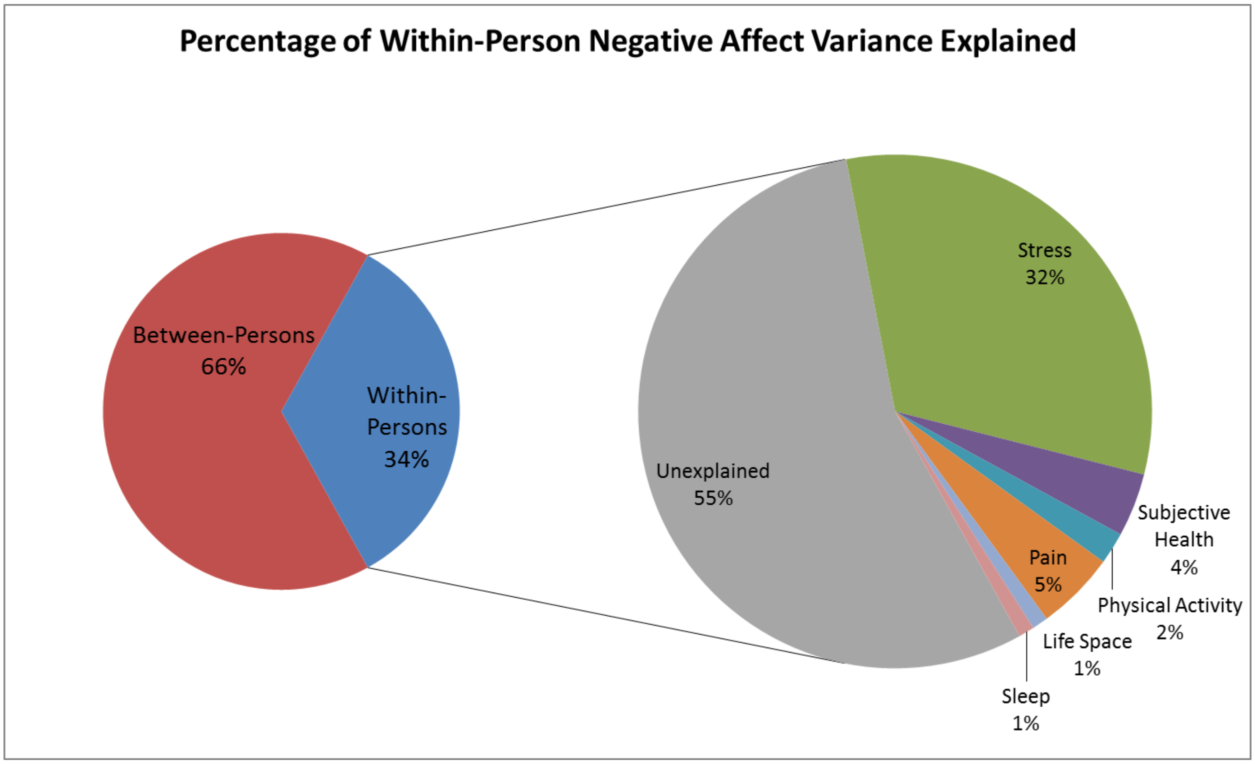

Figure 21. "Exploded" pie chart of the percentage of within-person positive affect variance explained by the predictors. The chart on the left is the total variance in positive affect partitioned into between-persons variance (66%) and within-persons variance (34%). The chart on the right is the within-person variance in NA, broken down into the explained (44% total) and unexplained (55%) variance. The explained variance percentages are the variance added (not orthoganol) as each predictor was included in the stepwise models. For NA, the order was Stress, Subjective Health, Physical Activity, Pain, Life Space, Social Activity, and Sleep. Social Activity is not depicted here because it explained <1% of the within-person variance.

How Frequently Do Positive and Negative Affect Vary?

A secondary research question was how frequently Positive and Negative Affect varied. To address this research question I did not calculate daily means for the variables, and as a result, only included the 3x per day variables (e.g., pain & stress) as Level 1 predictors in the multilevel models. Other than the granularity of the predictors (observation rather than daily aggregate), analysis procedures were the same in the models discussed in this section. See Appendix J for a description of the daily aggregate vs. observation model structures.

<u>Positive Affect – Observation Models</u>

As before, a null model was calculated to allow partitioning of the variance. Results from analysis of the null model indicated that 62% of the variance in PA was between-persons (τ_{00} = 0.36, z = 5.33, p < .001) and 38% was within-persons (σ^2 = .22, z = 39.91, p < .001). See Figure 22. Thus, there was sufficient within-person variability to justify further analyses.

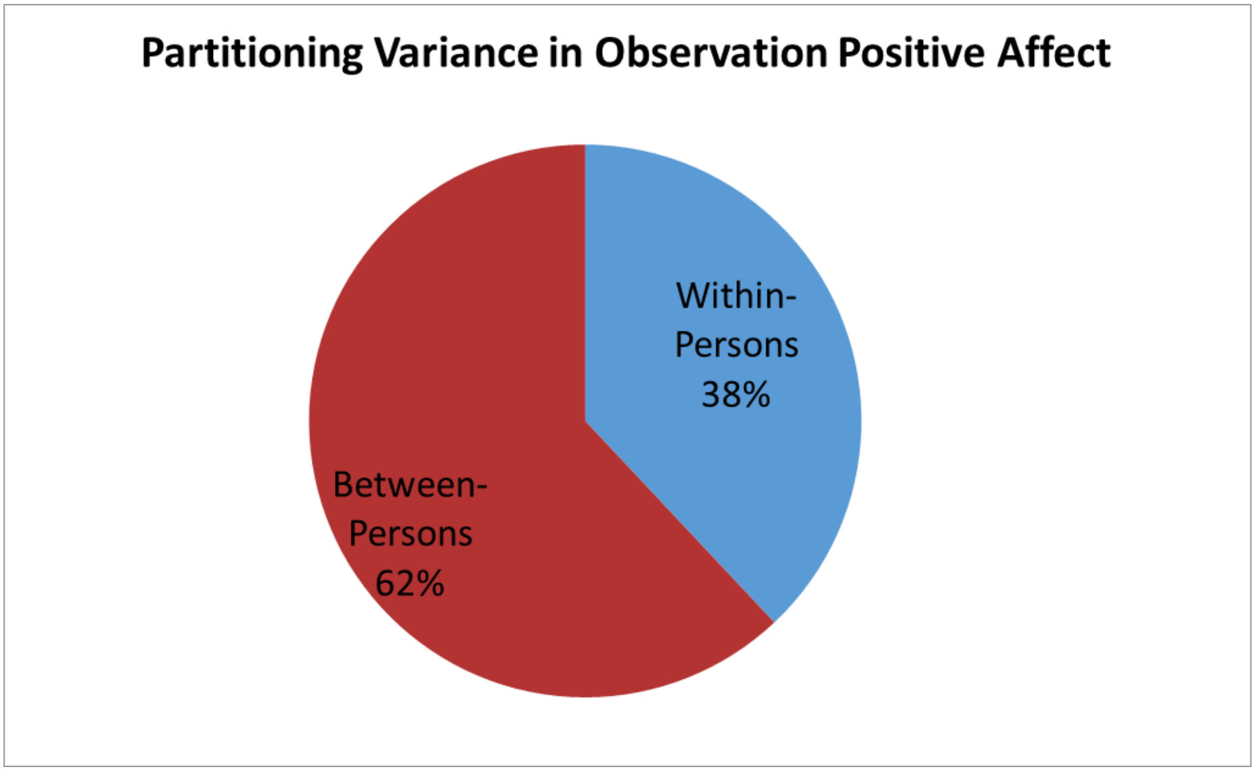

Figure 22. Partitioned Positive Affect variance in Observation models.

Pain. For the fixed effects model, pain significantly predicted positive affect (γ_{10} = -.10, *t* = -6.22, p < .001). Overall, on occasions when people reported greater physical pain, their PA was lower, such that for every 1 unit increase in pain, PA decreased by .10 units.

For the random effects model, the overall within-person relationship between pain and positive affect remained. However, there was significant slope variance (τ_{11} = .02, *t*=2.87, p=.002), indicating that there were between-person differences in within-person pain-PA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 4% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between pain and positive affect constrained to be equal across persons (X^2 (2) = 51.7, $p < .05$).

Stress. For the fixed effects model, stress did not significantly predict PA (γ_{10} = -.007, t = -.41, p=.68). Overall, the amount of stress a person reported on a given occasion did not relate to their PA at that time.

For the random effects model, the overall within-person relationship between stress and positive affect remained. However, there was significant slope variance (τ_{11} = .05, t=3.35, $p<.001$), indicating that there were between-person differences in within-person stress-PA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. Additionally, 5% of the within-person variance in PA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slope between stress and positive affect constrained to be equal across persons (X^2 (2) = 108.3, $p < .05$).

Full Models. As before, I also wanted to determine the unique effects of these predictors on the outcome variable. For the fixed full model, pain was the only significant unique predictor of PA (τ_{11} = -.10, t=-6.21, $p<.001$). The intercept for this model was 3.11, which in this case was the expected PA score when a person's pain and stress scores were both at their mean. For every 1 unit increase in pain, PA score could be expected to decrease by -.10 units.

For the random full model, pain remained the only significant unique fixed effect. However, there were between-person differences in the within-person relationships between these variables and PA. The slope variances for both Pain (τ_{11} = .02, t=2.80, p=.002) and Stress (τ_{22} = .04, t=3.29, p<.001) were significant, indicating that the within-person relationships between these variables and PA differed between people. For example, some people's PA might increase in response to stress, decrease in response to stress, or stay the same in response to stress. There was also a significant slope-intercept covariance for Stress (τ_{20} = -.06, t=-2.07, p<.05), such that the stress slopes were dependent on the PA intercepts and there was a "fanning in" at higher levels of stress. For those with high PA intercepts, PA decreased with increases in stress whereas those with low PA intercepts increased in PA with increases in stress. Additionally, the random full model accounted for 9% of the within-person variance in PA, and was a significantly better fit than the fixed model, which constrained the within-person relationships with PA to be the same across persons (X^2 (2) = 108.3, p <.05).

Negative Affect – Observation Model

Again, a null model was calculated to allow partitioning of the variance. Results from analysis of the null model indicated that 54% of the variance in NA was between-persons (τ_{00} = 0.003, z = 5.05, p < .001) and 46% was within-persons (σ^2 = .002, z = 39.13, p < .001). See Figure 23. Thus, there was sufficient within-person variability to justify further analyses.

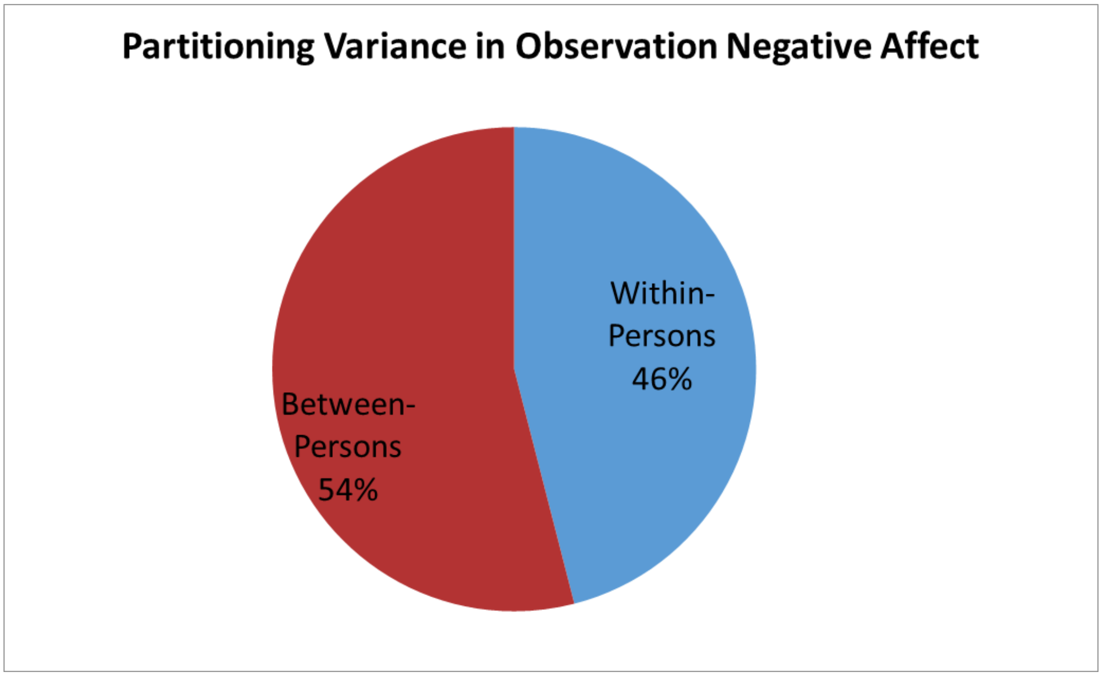

Figure 23. Partitioned Negative Affect variance in Observation models.

Pain. For the fixed effects model, pain significantly predicted negative affect (γ_{10} = .01, *t* = 5.66, p < .001). Overall, on occasions when people reported greater physical pain, their NA could be expected to be higher than their own average. This model explained 1% of the within-person variance in NA.

For the random effects model, the overall within-person relationship between pain and negative affect remained. However, there was also significant slope variance (τ_{11} = .0002, *t*=2.56, p<.05) indicating that there were between-person differences in within-person pain-NA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. This model explained 3% of the within-person variance in NA and was a significantly better fit than the fixed effects model ((X^2 (2) = 30.2, p<.05).

Stress. For the fixed effects model, stress significantly predicted NA (γ_{10} = .04, *t* = 23.66, p<.001). Overall, on occasions when people reported greater stress, their NA could be expected to be higher than their own average. This model explained 16% of the within-person variance in NA.

For the random effects model, the overall within-person relationship between stress and negative affect remained. However, there was also significant slope variance (τ_{11} = .001, *t*=3.26, p<.001) indicating that there were between-person differences in within-person stress-NA relationships such that although the average within-person relationship was positive, for some people it may have been negative or may not have existed at all. There was also significant slope-intercept covariance (τ_{10} = .0003, *t*=3.16, p=.002) such that the stress slopes were dependent on the person's NA intercept in a "fanning out" pattern. For those with high NA intercepts, NA increased with increases in stress whereas for those with low NA, intercepts decreased in NA with increases in stress. Additionally, 19% of the within-person variance in NA was accounted for by this model and allowing slopes to vary resulted in a better fit than the model with the slopes for the stress-negative affect relationships constrained to be equal across persons (X^2 (2) = 116, p <.05).

Full Models. For the fixed full model, pain (γ_{10} = .01, *t*=3.68, p<.001) and stress were significant unique predictors of NA (γ_{20} = .04, *t*=23.17, p<.001). Increases in NA could be expected on days when people were higher than their averages for stress and pain. This model explained 16% of the within-person variance in NA.

For the random full model, stress and pain remained significant unique predictors of NA. However, there were between-person differences in the within-person relationships between these variables and NA. The slope variances for both pain (τ_{11} = .0001, *t*=2.43, p=.008) and stress (τ_{22} = .001, t=3.30, p<.001) were significant, indicating that the within-person relationships between these variables and NA differed between people. There was also a significant slope-intercept covariance for Stress (τ_{20} = .0004, t=3.32, p<.001), such that the stress slopes were dependent on the NA intercepts and there was a "fanning out" at higher levels of stress. Those with high NA intercepts also tended to have larger stress-NA slopes while those with low NA intercepts tended to have smaller stress-NA slopes. Additionally, the random full model accounted for 20% of the within-person variance in NA, and was a significantly better fit than the fixed model, which constrained the within-person relationships with NA to be the same across persons (X^2 (2) = 92.2, p <.05).

<u>Summary</u>

Positive Affect. When comparing the best fitting daily aggregate vs. observation models for PA predicted by stress and pain (which were the random slopes models for both), observation models yielded slightly different effects than did the daily aggregate models (Table 6). For pain, when assessing within-person variability across the 20 days (daily aggregate model), the pain-PA slope variance was the only significant unique effect. When assessing within-person variability across the 60 observations (observation model), the fixed effect of pain was an additional significant unique predictor of PA. For stress, when assessing within-person variability across the 20 days the stress-PA slope variance was the only significant unique effect. When assessing within-person variability across the 60 observations, in addition to significant unique slope variance, there was significant unique slope-intercept covariance such that there was a fanning in at higher levels of stress.

Table 6. *Comparing Daily Aggregate vs. Observation Positive Affect Models for Pain and Stress*

Model	Pain (Daily Aggregate)	Pain (Observation)	Stress (Daily Aggregate)	Stress (Observation)
Significant Unique Effects	Slope Variance	Fixed Slope Variance	Slope Variance	Slope Variance Slope-Intercept Covariance

Negative Affect. When comparing the best fitting daily aggregate models vs. observation models (random slopes models for both) for NA predicted by pain and stress, observation models also yielded slightly different effects (Table 7). For pain, when assessing within-person variability across the 20 days (daily aggregate model), the pain-NA slope variance was the only significant unique effect. When assessing within-person variability across the 60 observations (observation model), the fixed effect of pain was an additional significant unique predictor of NA. For stress, there was a significant fixed effect and a significant slope variance when assessing within-person variability across the 20 days. When assessing within-person variability across the 60 observations, in addition to significant unique fixed effect and slope variance, there was significant unique slope-intercept covariance such that there was a fanning out at higher levels of stress.

Table 7. *Comparing Daily Aggregate vs. Observation Negative Affect Models for Pain and Stress*

Model	Pain (Daily Aggregate)	Pain (Observation)	Stress (Daily Aggregate)	Stress (Observation)
Significant Unique Effects	Slope Variance	Fixed Slope Variance	Fixed Slope Variance	Fixed Slope Variance Slope-Intercept Covariance

As stated previously, daily aggregate vs. observation models cannot be statistically compared for goodness of fit because transforming the variables into daily aggregates reduces the degrees of freedom substantially. For the same reason, it is not informative to compare the percentage of variance explained because observation models inherently have more variance to be explained. However, comparing which types of effects are significant in each of the models is still informative because it highlights that assuming assessing variance across days does not necessarily provide an accurate understanding of what predicts within-person variability in emotions.

CHAPTER 4

DISCUSSION

The rapidly growing proportion of older adults in the U.S. population (Health & Services, 2012) is a phenomenon that demands the identification of methods that can facilitate well-being in later life. Despite general declines in physical and cognitive functioning, emotional health remains relatively well-preserved in older adulthood in terms of both positivity and emotional stability (Carstensen et al., 2011). In the SAVI model, because failures to regulate everyday emotional experiences may have substantial physiological costs for older adults in particular, the preservation of emotional health is posited to be a specific strength of individuals in this demographic (Charles & Luong, 2013). Thus, the study of how emotions operate in daily life is enlightening as to how emotional preservation can be leveraged as a resource for maintaining health in older adulthood.

Indeed, positive and negative affect level and intraindividual variability are linked to physiological and psychological functioning (Bostic & Ptacek, 2001; Gruber et al., 2013; Steptoe et al., 2009; Wessman & Ricks, 1966). Affect IIV has received less empirical attention than affect level, yet it might tap into a distinct aspect of a person's emotional profile and can be reliably measured (Eid & Diener, 1999). Much of the previous research on affect IIV has focused on its relationship with distal variables such as personality (Murray, Allen, & Trinder, 2002) and mortality (Mroczek et al., 2015), as well as underlying biological mechanisms that covary with affect such as cortisol level (Steptoe et al., 2009). However, affect by definition is subject to frequent fluctuations (Diener, 2000), so to better understand these daily individual changes it was necessary to administer repeated assessments of affect and approximate predictors of change in a way that avoids the limitations of using indices such as the iSD (Eid & Diener, 1999).

A key component of the well-being paradox is the finding of greater emotional stability in older adults. Although this is generally the case, there may be individual differences in emotional stability (Kunzmann, Little, & Smith, 2000), so it was important to identify the characteristics of individuals who are more labile, and what causes lability. Intraindividual emotional fluctuations may be especially informative to investigate in older adult samples because of the aforementioned physiological vulnerabilities they may be prone to (Charles & Luong, 2013). To enable the potential for these individuals to maintain and even enhance their well-being, it was essential to first identify factors in older adults' daily lives that cause PA and NA to deviate from their normal levels and also, to explore possible between-person differences in the within-person relationships.

Therefore, the overall goal of this study was to extend theories of emotion by administering a broad assessment battery of proximal predictors of daily affect IIV in older adults. To this end, I administered frequent online surveys containing these predictors and analyzed affect IIV using a multilevel modeling approach. This allowed me to address the research questions regarding (a) if these older adults were significantly labile, (b) which factors were more emotionally evocative than others, and (c) if within-person relationships between these factors and affect differed across individuals. The present study was somewhat exploratory in nature, but I did have several main hypotheses that were generally confirmed. They were:

H1: Older adults will have significant IIV in both positive and negative affect.

H2: Health perceptions will significantly explain IIV in positive and negative affect.

H3: The factors that significantly predict affect IIV will differ between individuals.

Specific predictions were not made regarding daily activities, but life space in particular did have an impact on individuals' daily emotions. In the following sections, the primary findings of the present research are interpreted in the context of several leading theories of emotions in older adulthood. Implications for the development and design of emotion-based interventions and technologies are also discussed.

Older Adults Show Significant Intraindividual Variability in Affect

In support of Hypothesis 1, there was significant within-person variance in PA (Daily Aggregate Models = 22%, Observation Models = 38%) and NA (Daily Aggregate Models = 34%, Observation Models = 45%) in these older adults. The percentages observed in this study are comparable to previous findings from the few studies that investigated affect in healthy (cognitively intact) older adults using multilevel modeling and disclosed the intraclass correlation coefficients. These studies have reported 27% of the variance in PA being at the within-person level (Mccrae et al., 2008), and 46% (Neupert et al., 2007) to 48% (Mccrae et al., 2008) of the variance in NA being at the within-person level. This also coincides with findings that the percentage of within-person variance in NA tends to be higher than the within-person variance in PA. It has been suggested that NA may be more contextually driven (subject to within-person variation) whereas PA is "hard wired" and not as malleable to environmental conditions (Kolanowski, Hoffman, & Hofer, 2007). Worth note is that although the within-person variance in affect was significantly greater than 0, most of the total variance was still between-persons for both PA (Daily Aggregate Models = 78%, Observation Models = 62%) and NA (Daily Aggregate Models = 66%, Observation Models = 55%).

Longitudinal research using a measurement burst design with experience sampling over the course of 10 years has provided compelling evidence that emotional stability (using the mean square successive difference) increases over the life span (Carstensen et al., 2011). However, it is critical to acknowledge that there is explainable variance within-persons despite a general reduction in affect variability. That I was able to reject the null hypothesis (i.e. that all of the variance in affect would be between-persons) provides support for this claim; these older adults showed significant IIV in both PA and NA. Although this step in the analysis was necessary in determining the multilevel structure of the data, it also provides supportive evidence that older adults, whom are thought to be quite capable at regulating their emotions, do still show significant affect IIV. Furthermore, this is potentially predictable variance and these data support the growing body of evidence suggesting that intraindividual variability is not solely a product of random error, but is systematically associated with health-related variables (Ram & Gerstorf, 2009).

Assessment Frequency Considerations

In addition to providing evidence that older adults do show significant affect IIV, the present study had practical contributions that are relevant to designers of technologies or interventions that require monitoring emotions frequently. Because repeated measurement is a tedious process, it was important to obtain a sense of the assessment frequency necessary for the aforementioned designers to implement. That is, at what granularity was it possible to predict changes in affect and were there differences in the effects seen at different granularities? These questions are pertinent when considering tracking emotions over time; a person may be annoyed by having to answer questions about their stress and pain multiple times a day (e.g., if entering this information on a phone app or being asked these questions by a doctor or a robot), but they might be willing to share this information only once a day.

I was able to address this granularity issue for the stress and pain variables, and a key finding of the present study was the emergence of unique effects in the observation level of analyses. There were differences in the significant effects depending on if the models run were by daily aggregate (20-survey) or observation (60-survey) for both positive and negative affect (Table 7). As a result, it may be necessary for interventions or technologies to ask questions about pain and stress multiple times within a day to obtain a complete portrayal of emotional changes within an individual.

These findings are strengthened by the likelihood that the daily pain and stress scores in the present study were more accurate than typical daily assessments are. After all, the daily estimates here were an aggregate of three within-day assessments (i.e. "To what extent do you feel stressed at the present moment?"), whereas the typical daily assessment might ask a person "Over the last day, to what extent did you feel stressed?" Thus, it is possible that the significant daily effects would not have emerged at all had the questions been asked in the "Over the last day…" format, especially given findings that the emotional response to a stressor may dissipate over a relatively short amount of time (Scott, Sliwinski, & Blanchard-Fields, 2013).

Because this was a secondary research question, these were not formal analyses comparing fit for observation vs. daily aggregate models, but were simply assessing the differences in the significant unique predictors for each. Future research could use a more complex multilevel structure that is conducive to testing these effects directly, in which the proportions of the total variance within different time-levels (Level 1 = Observation, Level 2 = Day, Level 3 = Week, Level 4 = Month, etc.) could be distinguished.

Predictors of IIV Differ for PA & NA and Can Differ Between Individuals

The rationale behind the development of this study was that for an accurate representation of emotional states, it is necessary to allow there to be individual differences in how people respond emotionally to perceptions of health and daily events or activities. Indeed, two major findings were that (1) the isolated predictor random effects models were better representations of the observed data (with a few exceptions) than the fixed effects models and (2) the random effects models and the full PA and full NA models were both better fitting than their respective fixed effect models. That is, not only were there significant within-person associations between many of these predictors and affect overall, there were often significant between-person differences in the within-person relationships. Furthermore, many of these effects were unique after controlling for the other predictors (i.e., they persisted in the full models), including potential cross-level interactions. Whether increases in affect IIV are actually adaptive or maladaptive for physical health, in many cases it is contextually dependent (MacDonald & Stawski, 2014) and these results highlight the need to understand the factors that influence emotions at an individual level.

Additionally, the finding that the random effects models were generally better fitting in this demographic showcases the importance of considering individual differences even within an older subset of the population. Research has often focused on if and why older adults vary less than younger adults, (Carstensen et al., 2011; Fleeson & Jolley, 2006; Röcke et al., 2009), which are certainly vital questions to ask, but are not informative as to (a) which older adults are more emotionally reactive and (b) which daily stimuli predict these reactions more than others. The present investigation can inform the design of technologies and interventions being developed to improve well-being in older adults, based on findings that it cannot be assumed that the same daily event (e.g., traveling outside the home) or health perception (e.g., subjective physical health) will elicit the same affective response, or even that the same factors will predict changes in both PA and NA.

In general, the best predictors of IIV differed for PA and NA, further emphasizing the value in analyzing these components of affect separately (Watson et al., 1988). Subjective physical health and life space were the strongest fixed unique predictors of PA and stress was the strongest (and only) fixed unique predictor of NA in the full models. However, stress, pain, and subjective physical health had significant unique effects that were relevant (although not necessarily identical) in both PA and NA.

PA and NA Model Similarities

The only effects that *were* identical for both full models were the significant stress and pain slope variances. This further exhibits the benefit of implementing statistical methods that can model individual differences in within-person relationships. The individual slopes in Figure 14 show this pattern (see also Figures 5, 6, and 13 for other examples of significant slope variance). Specifically, NA increased on stressful days for most individuals, for a few individuals NA decreased on stressful days, and other's NA was not impacted at all by stress.

These results are interpretable within the framework of previous research on emotion regulation. Stress is very much an individualized process, and it is known that people appraise, perceive, and cope with stressors differently (Lazarus & Folkman, 1984; Neupert, Ennis, Ramsey, & Gall, 2015), which can depend on beliefs such as mastery and constraint and can influence the way those stressors manifest as emotions (Neupert et al., 2007; Urry & Gross, 2010). For example, more action-oriented coping dispositions in response to stressors are associated with higher levels of positive affect (Campbell-Sills, Cohan, & Stein, 2006). As such, possible causes of the significant stress slope variances may have been more favorable control beliefs or more efficient coping strategies for individuals whose affect was not impacted (slope of zero) or was impacted positively in response to stress (positive slope for PA and/or negative slope for NA), relative to those who reacted negatively (negative slope for PA and/or positive slope for NA).

Counterintuitive as it may be that certain individuals might respond positively to stress, such that PA be higher and/or NA be lower on stressful days, these findings align with evidence that positive emotions facilitate coping with stress (Folkman & Moskowitz, 2000). To explain, dynamic models of affect have suggested that on stressful days, the dependency between PA and NA increases, such that positive emotions are used as a resource for diminishing the negative emotions that occur as a result of stress (Ong, Bergeman, Bisconti, & Wallace, 2006; Reich, Zautra, & Davis, 2003). Furthermore, individuals who are more "resilient" are more likely implement this type of strategy (Tugade & Fredrickson, 2004), so the individual differences in stress-affect slopes observed in the present study could have been due to individual differences in resiliency or coping capabilities.

It is also important to highlight that although the stress-affect slope was negative for some individuals and positive for others, slope variance effects are not solely driven by a completely opposite slope. They can also be due to individual differences in slope magnitudes, regardless of polarity. For example, stress positively predicted NA overall, and although there were a few individuals whom had negative stress-NA slopes (lower NA on high-stress occasions), there were also differences in the rates of change for individuals whose slopes were in the same direction (i.e., people who reacted similarly in direction but differently in magnitude). This is critical to keep in mind, but does not change the interpretation of individual differences emotion regulation abilities (i.e., coping and resiliency) in response to stress, it simply highlights that some older adults are better at it than others. Being able to distinguish these individuals can allow for interventions to specifically target “low-copers” rather than expend time and resources on people who might not necessarily require such training.

It is also worth mentioning that for stress, intercept-slope covariance effects emerged in the observation models such that overall, individuals’ emotional reactivity to stress was dependent on their expected PA or NA level when their perceived stress was average. There are a number of ways in which an intercept-slope covariance would be observed, for example the “fanning in” pattern for PA could indicate decreases in PA on stressful days for high-PA individuals and increases in PA on stressful days for low-PA individuals (resulting in less between-person PA variance at high stress relative to between-person PA variance at average stress). This effect would also be observed if high-PA individuals’ PA was not affected by stress and low-PA individuals’ PA increased significantly in response to stress.

Resilient individuals tend to be high in PA, so the “fanning in” challenges some of the assumptions of the resiliency hypothesis, because PA would have been expected to increase in response to stress for high-PA individuals (who are presumably generating positive emotions to combat the negative effects of stress) and either be unchanged or decrease for low-PA individuals. The possible patterns of the “fanning out” effect for NA are a bit more consistent with a coping or resiliency framework, because the patterns would indicate increases in NA in response to stress for those who tend to be more negative and decreases in NA in response to stress for those who tend to be less negative (or at least increases that were more gradual than the high-NA individuals). Yet, in dynamic models of affect, the dependency between PA and NA may be greater in high-stress situations (Reich et al., 2003; Scott, Sliwinski, Mogle, & Almeida, 2014) so it may be that PA and NA cannot be interpreted as independent constructs when stress is higher than a person's average. Perhaps the high-PA individuals are also low-NA individuals and although their PA is depleted during stress, their general positivity prevents increases in NA. Because of these potential dependencies and that there are multiple patterns that could result in significant slope-intercept covariance, further analyses will be required to disambiguate these effects.

The other effect that emerged identically in both full models was the significant slope variance for pain, which can be interpreted similarly to the slope variance of stress. After all, being in physical pain is likely to be a stressor in itself. It is possible that individual differences in the emotional responses to pain were also driven by differences in coping abilities such that some people emotionally deal with pain better than others. Again, these findings emphasize the importance of looking at predictors of affect on an individual level, which can potentially provide insights into the causes of these differences. Identifying the higher level characteristics (e.g., coping strategies, social support) of those individuals whose PA is not influenced, or is for some reason positively influenced by increases in pain may be helpful in guiding well-being related interventions.

PA and NA Model Differences

Other than the pain and stress slope variances, the unique significant effects that persisted in both full models differed for PA and NA. Subjective health was the best overall predictor of PA, and occurred in the expected positive manner. There is general consistency in the finding that subjective health ratings are positively related to positive affect (Diener & Chan, 2011; Watson et al., 1988; Zautra, Johnson, & Davis, 2005), so it would have been somewhat surprising if there were individual differences in this fixed effect.

However, that was the case for the NA model, in which subjective health's influence on negative emotions differed across individuals. One can speculate reasons for observing this effect. For example, it could be that some of these older adults have strong social support networks that help them deal with perceived health declines (Bisconti & Bergeman, 1999) and as a result, their NA was not impacted as severely as individuals without such support systems.

The mere existence of the slope variance effect in this case is particularly insightful in conjunction with the fact that the fixed effect was *not* significant in the full NA model. If a less rigorous data analysis technique been implemented, I would have observed no overall effect of subjective health on NA. As such, I would have been unable to reject the null hypothesis that no significant relationship between subjective health and NA existed even though for these older adults it did, but only for certain individuals.

Perhaps the most interesting finding was the emergence of life space as a significant predictor of PA, even when controlling for all of the other variables. For these older adults, positive affect increased on days in which they traveled greater distances from their bedrooms than they did on an average day. However, the slope variance indicated that this relationship varied significantly between people. Life space was developed as a measure of mobility and physical functioning, but also correlates negatively with depression and positively with cognitive functioning (Baker, Bodner, & Allman, 2003). Loss of mobility in older adulthood (e.g. driving cessation) has been shown to correlate with negative emotional outcomes (Anstey, Windsor, Luszcz, & Andrews, 2006 Andrews, 2006), but this is the first known study that empirically tested and identified life space as a predictor of affect IIV.

Given the novelty of this finding, and that the slopes differed between people, the relationship between life space and affect in older adults warrants further investigation. One of the proposed mechanisms underlying the stability of affect in older adulthood is that these individuals' environmental contexts become more stable and predictable (Fleeson & Jolley, 2006). However, the older adults in this study showed that on average, they *were* actively introducing unpredictability into their environments. That is, individuals' daily maximum life spaces were often outside of their homes (i.e., places in their neighborhoods and towns) and generally speaking, traveling to further life spaces than their own averages resulted in increases in PA.

Regarding the slope variance, it makes sense intuitively that traveling further outside the home would lead to different emotional outcomes depending on the individual, and there are a number of potential explanations for what drove these individual differences. One is that the individual differences in slopes could have been due to differences in person-environment fit (Lawton & Nahemow, 1973), such that emotional positivity in response to increasing life space occurred only for individuals (or to a greater extent for individuals) whom had the capacity to handle the pressures of the environment. Future analyses might be able to test this by looking at an interaction between life space and a fit-related variable such as subjective health. One might expect that those who are subjectively less healthy are ill-fit to travel to further distances than they are accustomed to. As a result, ill-fit individuals might be expected to show no PA benefit (and potentially a PA decline) on days in which greater life spaces are achieved.

The significant life space effects are practically relevant because it is the one of the only variables measured that can be accurately estimated without the need to directly ask a person how far they traveled on a given day. Using a smart watch or phone with GPS enabled one could tell how far a person traveled and also, likely what the means of transportation was (based on the amount of time it took to get there). Future research should focus on identifying these types of factors that predict emotional health and can be passively measured, because they have the potential to be the hallmarks of efforts to promote well-being in aging populations.

Summary

In the isolated predictor models, health perceptions significantly explained intraindividual variation in affect, which was in support of Hypothesis 2. This statement was more accurate of PA than of NA, for which sleep quality was not a significant predictor. Specific hypotheses were not made regarding the daily activities, and I was unable to reject the null hypotheses regarding the impact of social and physical activity on affect. However, life space was a daily activity that *was* a significant unique predictor of PA IIV.

Many of the effects of the isolated models persisted in the full models, which is an important contribution because previous studies have seldom (if at all) administered as wide a set of daily measures and used a multilevel approach, allowing the possibility of random effects. Thus, I was able to understand the significant *unique* proximal predictors of within-person affect after partialling out the explained variance that was shared amongst them. This might explain instances in which the present results did not replicate previous the findings of previous studies that did not include a broad array of proximal covariates. For example, the finding that daily sleep quality predicts within-person PA (Mccrae et al., 2008) was seen here only in the isolated variable model, not after controlling for the effects of the other variables.

In support of Hypothesis 3, unique random effects persisted in the full models and differed slightly for PA and NA. However, pain and stress had consistent random effects in both PA and NA. This highlights their unique linkages to emotions but also supports the idea that the strength of such linkages differs per individual. The results of this study provide critical insights into which short-term variables explain PA and NA IIV and as such, which relationships require further probing to determine the underlying causes of older individuals' differential emotional responses to daily events and health perceptions.

Conclusion

A primary takeaway from this study is that our understanding of the role daily events and perceptions of health play in older adults' emotional oscillations is severely limited when using a "one size fits all" approach. There was significant IIV for both PA and NA, and the nature of these within-person fluctuations varied between individuals. The full daily aggregate random slopes models significantly accounted for a greater percentage of the within-person variance than the fixed models in PA (32% vs. 20%) and in NA (45% vs. 30%). Additionally, certain factors were more predictive of PA IIV and others of NA IIV. Assessing these variables multiple times within and across days over the course of a month provided a critical first step toward conceptualizing a framework of intraindividual variability in affect and its relationship to health in older adults. The results of the present study unveiled short-term predictors of affect variability, which could potentially be implemented in a continuous health-monitoring technology such as a phone application or robot that collects data on daily emotions and the factors that lead to fluctuations in these emotions.

Because these results suggest that relationships between certain variables and affect IIV may not be consistent across persons, they provide insights into the development of effective health-monitoring technologies that account for these between-person differences (and between-person consistencies) in the within-person relationships. In tracking PA for example, the link with Subjective Health was strong and consistent across persons so this would likely be a variable that you would want to assess in everyone. Pain on the other hand, showed significant slope variance for both PA and NA. Thus, it might be inefficient for a health-monitoring technology to track pain for everyone (e.g., someone whose affect was unchanged on days of higher or lower levels of pain than their own average).

To maximize efficiency of such technologies, it would be beneficial to identify which individual's emotions are subject to fluctuate in response to varying levels of pain. Trait measures were administered to these participants, so this is something that can be addressed in future directions. To illustrate, something such as living situation might explain which people's emotions deviate as pain increases, such that older adults living alone respond emotionally negative on days when they experience more pain than average whereas individuals living with a spouse are emotionally unchanged by increases in pain.

As technological advancements and increasing availability of devices such as wearables and phone applications allow these daily factors to be measured more frequently, knowledge of which factors are relevant for certain individuals will enable creators of these technologies to make informed design decisions. Perhaps an intervention or health-monitoring technology can "calibrate" the questions it asks based on an initial setup phase, in which people create user profiles based on assessments of demographics or personality-type, among others. In repeated assessments, time and annoyance are things to consider, so it is just as important to know what *not* to ask as it is to know what to ask.

Indeed, annoyance was a factor of consideration when developing the daily surveys. In attempt to minimize disruption in participants' daily lives, not all potentially significant predictors of affect IIV were included (e.g., diet, social support, time spent doing hobbies). I did not want each survey to become so tedious for people that they ended up skipping a substantial number of surveys. It is likely though that some of the omitted factors may have been able to account for some of the unexplained within-person variance (68% for PA, 55% for NA) that remained in the full models.

However, as previously stated, this was the most comprehensive battery that has been administered multiple times per day in a study of older adults' emotions. The factors included were previously identified as being subject to vary within a day and across days (e.g., stress, subjective health), and likely to have an impact on emotions. Additionally, many of these factors could be easily modified by the individual (e.g., life space), whereas some of those omitted may be less controllable (e.g., social support).

Another annoyance-related limitation was that by only administering some of the factors 3x per day (affect, pain, and stress), I somewhat constrained the possible within-day variability. To explain, I could not investigate Level 1 relationships with affect for the 1x per day variables (subjective health, life space, physical activity, social activity) in the observation models. Because these participants were highly compliant (91% response rate after data cleaning), I may have been able to include more questions at each time point (e.g., "How much social activity did you engage in since the last assessment?"). However, there is no way of knowing if doing so would have negatively affected the response rate.

Although the present analyses were able to determine the percentage of affect IIV explained by these short-term factors, it will also be informative to determine if these factors specifically predict more variability or less variability within a person on a given day. Future analyses will be conducted to more directly predict affect IIV in this way. This can be done by creating an affect variability score (iSD) for every person on every day. However, said analysis might be limited in power given that there were a maximum of 3 affect scores each day, so even if a person only missed one survey that day, the full day would need to be omitted (since SD requires at least 3 data points).

The ultimate goal of research on affect IIV is to be able to identify when a deviation from one's optimal level becomes indicative of a threat to one's health, which was not directly investigated in the present study. Thus, another possibility is to use these daily affect IIV scores as predictors of subjective health. In doing so, it can be determined if health was impacted on days when people were more or less variable that their own average and consequently, identify if high IIV was adaptive or maladaptive for these older adults (fixed effect) or for some but not others (random effects).

The logical first step toward accomplishing this goal was to understand (a) what predicted within-person variability in the first place, (b) the strengths of these relationships for the two components of affect, and (c) if the factors influencing affect variability differed between individuals. The findings of this research have expanded upon existing theories of emotions. Additionally, applying these findings can help guide the development of personalized technologies and interventions that have the potential to aid older adults' maintenance of healthy emotional profiles. Individualized feedback on the different causes of positive and negative emotional deviations can enable older adults to directly identify specific activities as regulation targets and consequently, allow for a more successful physical and psychological aging process.

APPENDIX A: INITIAL ASSESSMENTS

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Welcome!

Thank you for participating in our survey. Your feedback is very important to us.

* 1. Please enter your username below. This is the username you created on the first day of this research study. As a reminder, it contains the answer to one of three questions (your first pet's name, your high school mascot, or the street you grew up on) followed by your 4-digit year of birth (not case sensitive).

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Demographics and Health

This questionnaire asks you to provide information about various aspects of your background, including your demographic and health information. Please answer the questions by entering or selecting the appropriate response.

Published documents regarding these answers will not identify individuals with their answers. However, if there is a question that you do not wish to answer, please leave it blank and go on to the next question.

* 2. Gender:

- ◯ Female
- ◯ Male

* 3.

What is your date of birth?

	MM		DD		YYYY
Date	[ ]	/	[ ]	/	[ ]

* 4. Are you fluent in English?

- ◯ Yes
- ◯ No

* 5. What is your preferred language for communicating?

- ◯ English
- ◯ Spanish
- ◯ American Sign Language
- ◯ Other (please list)

[ ]

* 6. What is your highest level of education?

- ◯ No formal education
- ◯ Less than high school graduate
- ◯ High school graduate/GED
- ◯ Vocational training
- ◯ Some or in-progress college/Associate's degree
- ◯ Bachelor's degree (BA, BS)
- ◯ Master's degree (or other post-graduate training)
- ◯ Doctoral degree (PhD, MD, EdD, DDS, JD, etc)
- ◯ Do not wish to answer

* 7. Current marital status (check one)

- ◯ Single
- ◯ Married
- ◯ Separated
- ◯ Divorced
- ◯ Widowed
- ◯ Do not wish to answer
- ◯ Other (please specify)

* 8. Do you consider yourself Hispanic or Latino?

◯ Yes ◯ No ◯ Do not wish to answer

* 9. How would you describe your primary racial group?

- ◯ American Indian/Alaska Native
- ◯ Asian
- ◯ Black or African American
- ◯ Native Hawaiian or Other Pacific Islander
- ◯ White
- ◯ More than one race
- ◯ Do not wish to answer
- ◯ Other (please specify)

* 10. In which type of housing do you live?

- ◯ Single family home
- ◯ Apartment or Condominium
- ◯ Assisted living residence
- ◯ Nursing home residence
- ◯ Do not wish to answer
- ◯ Other (please specify)

* 11. Which one of the following BEST describes your living arrangement?

- ◯ Living alone
- ◯ Living with your immediate family (i.e., spouse/partner and/or dependent children, or parents if never married)
- ◯ Living with your adult children
- ◯ Living with your (or your spouse/partner's) extended family (e.g., parents, siblings, cousins)
- ◯ Living with roommate(s)
- ◯ Do not wish to answer
- ◯ Other (please specify)

* 12. Is your housing or community specifically designed for seniors (i.e., 55 and older)?

- ◯ Yes ◯ No ◯ Not sure

* 13. What is your primary mode of transportation? (Check one)

- ◯ Drive myself
- ◯ A friend or family member drives me
- ◯ Walk
- ◯ Bicycle
- ◯ Taxi
- ◯ Use transportation service provided by my residence
- ◯ Use public transportation (e.g., bus, subway, van services)
- ◯ Other (please specify)

* 14. Which category best describes your yearly household income? Do not give the dollar amount, just check the category.

- ◯ Less than $25,000
- ◯ $25,000 - $49,999
- ◯ $50,000 - $74,999
- ◯ $75,000 or more
- ◯ Do not wish to answer
- ◯ Do not know for certain

* 15. What is your primary occupational status? (Check one)

- ◯ Employed full-time
- ◯ Employed part-time
- ◯ Student
- ◯ Homemaker
- ◯ Retired
- ◯ On maternity leave, on sick leave, or on disability benefits
- ◯ Unemployed or temporarily laid off
- ◯ Other (please specify)

16. If employed full-time, what is your occupation?

17. If employed part-time, what is your occupation?

18. If retired, what was your former occupation? In what year did you retire?

* 19. In general, would you say your health is:

- ◯ Poor
- ◯ Fair
- ◯ Good
- ◯ Very good
- ◯ Excellent

* 20. Compared to other people your own age, would you say your health is:

- ◯ Poor
- ◯ Fair
- ◯ Good
- ◯ Very good
- ◯ Excellent

* 21. How often do health problems stand in the way of your doing the things you want to do?

- ◯ Never
- ◯ Seldom
- ◯ Sometimes
- ◯ Often
- ◯ Always

* 22. How satisfied are you with your present health?

- ◯ Not at all satisfied
- ◯ Not very satisfied
- ◯ Neither satisfied nor dissatisfied
- ◯ Somewhat satisfied
- ◯ Extremely satisfied

* 23. How many different **prescription medications** do you take <u>each day</u>?

[ ]

* 24. How many different over-the-counter medications/supplements do you take <u>each day</u>?

[ ]

* 25. Please indicate if you have ever been told by a health professional that you have any of the following conditions. Check <u>one</u> for each condition.

	Yes	No	Do not wish to answer/Not sure
Alzheimer's disease	◯	◯	◯
Arthritis	◯	◯	◯
Asthma	◯	◯	◯
Cancer	◯	◯	◯
Cardiac Atrial Fibrillation/Cardiac Arrhytmia	◯	◯	◯
Chronic Kidney Disease	◯	◯	◯
Chronic Obstructive Pulmonary Disease (COPD)	◯	◯	◯
Coronary Artery Disease/Coronary Heart Disease	◯	◯	◯
Depression	◯	◯	◯
Diabetes/High Blood Sugar	◯	◯	◯
Heart Failure/Congestive Heart Failure	◯	◯	◯
High Blood Pressure/Hypertension	◯	◯	◯
High Cholesterol/Hyperlipidemia	◯	◯	◯
Osteoporosis	◯	◯	◯
Overweight	◯	◯	◯
Stroke/Transient Ischemic Attack	◯	◯	◯

Other? If yes, please list below

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Technology Experience Profile

The purpose of this set of questions is to assess your familiarity and experience with technology. The following questions list technologies from different areas. Please select the most appropriate response to indicate how much you have used the technology listed, within the last 12 months.

* 26. Within the last 12 months, how much have you used communication technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Answering Machine/Voicemail (e.g., record and retrieve messages) *with or without video relay service	○	○	○	○	○
Automated Telephone Menu System (e.g., pay bills, refill prescriptions) *with or without video relay service	○	○	○	○	○
Fax (e.g., receive and send printed documents)	○	○	○	○	○
Mobile Phone (e.g., make and receive calls) *with or without video relay service	○	○	○	○	○
Text Messaging (e.g., phone texting, BBM, iMessage, SMS)	○	○	○	○	○
Video call/conferencing (e.g., Skype, Facetime)	○	○	○	○	○

* 27. Within the last 12 months, how much have you used computer technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Desktop/Laptop Computer	○	○	○	○	○
Tablet Computer (e.g., iPad, Surface)	○	○	○	○	○
Email (e.g., Gmail, Yahoo)	○	○	○	○	○
Photo/Video Software (e.g., editing, organizing; iPhoto, Picture Manager, Photoshop)	○	○	○	○	○
Productivity Software (e.g., Excel, PowerPoint, Quicken, TurboTax, Word)	○	○	○	○	○
Social Networking (e.g., Facebook, MySpace)	○	○	○	○	○

* 28. Within the last 12 months, how much have you used everyday technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Automatic Teller Machine (ATM)	○	○	○	○	○
Photocopier (e.g., Lexmark, Xerox)	○	○	○	○	○
Home Security System (e.g., Ackerman Security, ADT)	○	○	○	○	○
In-Store Kiosk (e.g., grocery self-checkout, price checker)	○	○	○	○	○
Microwave Oven	○	○	○	○	○
Programmable Device (e.g., coffee maker, thermostat)	○	○	○	○	○

* 29. Within the last 12 months, how much have you used health technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Blood Pressure Monitor (e.g., measure blood pressure)	○	○	○	○	○
Digital Thermometer (e.g., measure temperature)	○	○	○	○	○
Health Management Software (e.g., to keep track of weight, diet, exercise; Personal Health Record)	○	○	○	○	○
Heart Rate Monitor (e.g., measure heart rate, pulse)	○	○	○	○	○
Medication Reminder Device (e.g., schedule electronic alerts)	○	○	○	○	○
Pedometer (e.g., measure walking distance)	○	○	○	○	○

* 30. Within the last 12 months, how much have you used recreational technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Digital Music Player (e.g., iPod, MP3 player, Zune, tablet)	○	○	○	○	○
Digital Photography (e.g., camera, tablet, phone)	○	○	○	○	○
Electronic Book Reader (e.g., Kindle, Nook, tablet)	○	○	○	○	○
Gaming Console (e.g., Playstation, Wii, XBox)	○	○	○	○	○
Online Shopping/Coupons (e.g., Amazon, Groupon, retail stores)	○	○	○	○	○
Recording and Playback Device (e.g., Blu-Ray, CD, DVD, DVR, VCR)	○	○	○	○	○

* 31. Within the last 12 months, how much have you used transportation technology?

	Not sure what it is	Not used	Used once	Used occasionally	Used frequently
Airline Kiosk (e.g., check in, print boarding pass)	○	○	○	○	○
Bus Tracker (e.g., check location of buses, estimate time of arrival)	○	○	○	○	○
Online Map Software (e.g., get directions, plan routes; Google Maps, MapQuest)	○	○	○	○	○
In-Vehicle Navigation System/GPS	○	○	○	○	○
Online Travel Reservation (e.g., airline website, Expedia, Travelocity)	○	○	○	○	○
Parking Payment System (e.g., exiting lot, paying for space)	○	○	○	○	○

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Satisfaction With Life Scale

Below are five statements that you may agree or disagree with. Please indicate your agreement with each statement by selecting the appropriate response. Please be open and honest in your responding.

* 32. In most ways my life is close to my ideal.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Slightly disagree
- ◯ Neither agree not disagree
- ◯ Slightly agree
- ◯ Agree
- ◯ Strongly agree

* 33. The conditions of my life are excellent.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Slightly disagree
- ◯ Neither agree not disagree
- ◯ Slightly agree
- ◯ Agree
- ◯ Strongly agree

* 34. I am satisfied with my life.

- Strongly disagree
- Disagree
- Slightly disagree
- Neither agree not disagree
- Slightly agree
- Agree
- Strongly agree

* 35. So far I have gotten the important things I want in life.

- Strongly disagree
- Disagree
- Slightly disagree
- Neither agree not disagree
- Slightly agree
- Agree
- Strongly agree

* 36. If I could live my life over, I would change almost nothing.

- Strongly disagree
- Disagree
- Slightly disagree
- Neither agree not disagree
- Slightly agree
- Agree
- Strongly agree

Georgia Tech

Personality Inventory

Here are a number of personality traits that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

* 37. I see myself as extraverted, enthusiastic.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 38. I see myself as critical, quarrelsome.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 39. I see myself as dependable, self-disciplined.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 40. I see myself as anxious, easily upset.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 41. I see myself as open to new experiences, complex.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 42. I see myself as reserved, quiet.

- ◯ Disagree strongly
- ◯ Disagree moderately
- ◯ Disagree a little
- ◯ Neither agree nor disagree
- ◯ Agree a little
- ◯ Agree moderately
- ◯ Agree strongly

* 43. I see myself as sympathetic, warm.

- ◯ Disagree strongly
- ◯ Disagree moderately
- ◯ Disagree a little
- ◯ Neither agree nor disagree
- ◯ Agree a little
- ◯ Agree moderately
- ◯ Agree strongly

* 44. I see myself as disorganized, careless.

- ◯ Disagree strongly
- ◯ Disagree moderately
- ◯ Disagree a little
- ◯ Neither agree nor disagree
- ◯ Agree a little
- ◯ Agree moderately
- ◯ Agree strongly

* 45. I see myself as calm, emotionally stable.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

* 46. I see myself as conventional, uncreative.

- Disagree strongly
- Disagree moderately
- Disagree a little
- Neither agree nor disagree
- Agree a little
- Agree moderately
- Agree strongly

Georgia Tech

Affect Intensity Measure

The following questions refer to emotional reactions to typical life-events. Please indicate how YOU react to these events by placing a number from the following scale in the blank space preceding each item. Please base your answers on how YOU react, not on how you think others react or how you think a person should react.

* 47. When I accomplish something difficult I feel delighted or elated.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 48. When I feel happy it is a strong type of exuberance.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 49. I enjoy being with other people very much.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 50. I feel pretty bad when I tell a lie.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 51. When I solve a small personal problem, I feel euphoric.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 52. My emotions tend to be more intense than those of most people.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 53. My happy moods are so strong that I feel like I'm in heaven.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 54. I get overly enthusiastic.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 55. If I complete a task I thought was impossible, I am ecstatic.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 56. My heart races at the anticipation of some exciting event.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 57. Sad movies deeply touch me.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 58. When I'm happy it's a feeling of being untroubled and content rather than being zestful and aroused.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 59. When I talk in front of a group for the first time my voice gets shaky and my heart races.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 60. When something good happens, I'm usually much more jubilant than others.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 61. My friends might say I'm emotional.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 62. The memories I like the most are of those times when I felt content and peaceful rather than zestful and enthusiastic.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 63. The sight of someone who is hurt badly affects me strongly.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 64. When I'm feeling well it's easy for me to go from being in a good mood to being really joyful.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 65. "Calm and cool" could easily describe me.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 66. When I'm happy I feel like I'm bursting with joy.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 67. Seeing a picture of some violent car accident in a newspaper makes me feel sick to my stomach.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 68. When I'm happy I feel very energetic.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 69. When I receive a reward I become overjoyed.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 70. When I succeed at something, my reaction is calm and contentment.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 71. When I do something wrong I have strong feelings of shame and guilt.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 72. I can remain calm even on the most trying days.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 73. When things are going good I feel 'on top of the world'.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 74. When I get angry it's easy for me to still be rational and not overreact.

Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

* 75. When I know I have done something very well, I feel relaxed and content rather than excited and elated.

Never Almost Never Occasionally Usually Almost Always Always

* 76. When I do feel anxiety it is normally very strong.

Never Almost Never Occasionally Usually Almost Always Always

* 77. My negative moods are mild in intensity.

Never Almost Never Occasionally Usually Almost Always Always

* 78. When I am excited over something I want to share my feelings with everyone.

Never Almost Never Occasionally Usually Almost Always Always

* 79. When I feel happiness, it is a quiet type of contentment.

Never Almost Never Occasionally Usually Almost Always Always

* 80. My friends would probably say I'm a tense or 'high-strung' person.

Never Almost Never Occasionally Usually Almost Always Always

* 81. When I'm happy I bubble over with energy.

Never Almost Never Occasionally Usually Almost Always Always

* 82. When I feel guilty, this emotion is quite strong.

Never Almost Never Occasionally Usually Almost Always Always

* 83. I would characterize my happy moods as closer to contentment than joy.

Never Almost Never Occasionally Usually Almost Always Always

* 84. When someone compliments me, I get so happy I could 'burst'.

Never Almost Never Occasionally Usually Almost Always Always

* 85. When I am nervous I get shaky all over.

Never Almost Never Occasionally Usually Almost Always Always

* 86. When I am happy the feeling is more like contentment and inner calm than one of exhilaration and excitement.

◯ Never ◯ Almost Never ◯ Occasionally ◯ Usually ◯ Almost Always ◯ Always

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Trait Anxiety Inventory

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do no spend too much time on any one statement but give the answer which seems to describe how you generally feel.

* 87. I feel pleasant.

- Almost never
- Sometimes
- Often
- Almost always

* 88. I feel nervous and restless.

- Almost never
- Sometimes
- Often
- Almost always

* 89. I feel satisfied with myself.

- Almost never
- Sometimes
- Often
- Almost always

* 90. I wish I could be as happy as others seem to be.

- Almost never
- Sometimes
- Often
- Almost always

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Perceived Stress Scale

The questions in the scale ask you about your feelings and thoughtsduring the last month. In each case, you will be asked to indicate by selecting *how often* you felt or thought a certain way.

* 107. In the last month, how often have you been upset because of something that happened unexpectedly?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 108. In the last month, how often have you felt that you were unable to control the important things in your life?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 109. In the last month, how often have you felt nervous and "stressed"?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 110. In the last month, how often have you felt confident about your ability to handle your personal problems?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 111. In the last month, how often have you felt that things were going your way?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 112. In the last month, how often have you found that you could not cope with all the things that you had to do?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 113. In the last month, how often have you been able to control irritations in your life?

- ◯ Never
- ◯ Almost Never
- ◯ Sometimes
- ◯ Fairly Often
- ◯ Very Often

* 114. In the last month, how often have you felt that you were on top of things?

- Never
- Almost Never
- Sometimes
- Fairly Often
- Very Often

* 115. In the last month, how often have you been angered because of things that were outside of your control?

- Never
- Almost Never
- Sometimes
- Fairly Often
- Very Often

* 116. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

- Never
- Almost Never
- Sometimes
- Fairly Often
- Very Often

APPENDIX B: BASELINE TRAIT DESCRIPTIVE INFORMATION

Assessment	Measure	Mean	Standard Deviation	Range
Affect Intensity[a]		3.49	0.50	2.4 – 4.7
Life Satisfaction[b]		25.93	6.36	7-35
Personality[c]	Extraversion	4.76	1.42	1.5-7
	Agreeableness	5.73	1.04	3.5-7
	Conscientiousness	6.21	0.91	4.5-7
	Emotional Stability	5.71	1.14	2.5-7
	Openness	5.47	1.02	3.5-7
Trait Anxiety[d]		32.98	8.75	22-59
Trait Stress[e]		10.73	6.15	3-29

a: 1 = never, 2 = almost never, 3 = occasionally, 4 = usually, 5 = almost always, 6 = always
b: Sum of five items. 5-9 = extremely dissatisfied, 10-14 = dissatisfied, 15-19 slightly dissatisfied, 20 = neutral, 21-25 = slightly satisfied, 26-30 = satisfied, 31-35 = extremely satisfied
c: 1 = disagree strongly, 4 = neither agree nor disagree, 7 = agree strongly
d: Sum of twenty items. 1 = almost never, 2 = sometimes, 3 = often, 4 = almost always
e: Sum of ten items. 0 = never, 1 = almost never, 3 = sometimes, 4 = fairly often, 5 = very often

APPENDIX C: MORNING SURVEY

SWB (T1)

Welcome.

Thank you for participating in our survey. Your feedback is very important to us. When completing the survey, remember that we are just interested in your immediate reactions to these questions. Keep in mind that you are required to answer each question and will not be able to return to previous questions after answering.

1. Please enter the username that you created for yourself (not case sensitive).

2. What time did you wake up this morning?

	HH		MM	AM/PM
Time		:		

3. How well did you sleep last night?

Worst Possible Sleep ○ ○ ○ ○ ○ Best Possible Sleep

4. To what extent do you feel *excited* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

5. To what extent do you feel *determined* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

6. To what extent do you feel *nervous* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

Page 1

SWB (T1)

7. To what extent do you feel *afraid* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

8. To what extent do you feel *interested* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

9. To what extent do you feel *active* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

10. To what extent do you feel *upset* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

11. To what extent do you feel *attentive* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

12. To what extent do you feel *hostile* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

13. To what extent do you feel *ashamed* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

SWB (T1)

14. To what extent do you feel in *physical pain* at the present moment?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

15. To what extent do you feel *stressed* at the present moment?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

16. To what extent do you feel *happy* at the present moment?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

17. To what extent do you feel *sad* at the present moment?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

APPENDIX D: AFTERNOON SURVEY

SWB (T2) - With Obj. Health

Welcome.

Thank you for participating in our survey. Your feedback is very important to us. When completing the survey, remember that we are just interested in your immediate reactions to these questions. Keep in mind that you are required to answer each question and will not be able to return to previous questions after answering.

1. Please enter your user name (not case sensitive).

2. To what extent do you feel *excited* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

3. To what extent do you feel *determined* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

4. To what extent do you feel *nervous* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

5. To what extent do you feel *afraid* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

6. To what extent do you feel *interested* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

Page 1

SWB (T2) - With Obj. Health

7. To what extent do you feel *active* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

8. To what extent do you feel *upset* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

9. To what extent do you feel *attentive* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

10. To what extent do you feel *hostile* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

11. To what extent do you feel *ashamed* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

12. To what extent do you feel in *physical pain* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

13. To what extent do you feel *stressed* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

Page 2

SWB (T2) - With Obj. Health

14. To what extent do you feel *physically strong* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

15. To what extent do you feel *physically rested* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

16. To what extent do you feel *physically healthy* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

17. To what extent do you feel *happy* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

18. To what extent do you feel *sad* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

SWB (T2) - With Obj. Health

19. The following items are about activities you might do during a typical week. Over the past week, did your physical health limit you in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	○	○	○
Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	○	○	○
Lifting or carrying groceries	○	○	○
Climbing several flights of stairs	○	○	○
Climbing one flight of stairs	○	○	○
Bending, kneeling, or stooping	○	○	○
Walking more than a mile	○	○	○
Walking several blocks	○	○	○
Walking one block	○	○	○
Bathing or dressing yourself	○	○	○

APPENDIX E: EVENING SURVEY

SWB (T3)

Welcome.

Thank you for participating in our survey. Your feedback is very important to us. When completing the survey, remember that we are just interested in your immediate reactions to these questions. Keep in mind that you are required to answer each question and will not be able to return to previous questions after answering.

1. Please enter your user name (not case sensitive).

2. To what extent do you feel *excited* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

3. To what extent do you feel *determined* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

4. To what extent do you feel *nervous* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

5. To what extent do you feel *afraid* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

6. To what extent do you feel *interested* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

Page 1

SWB (T3)

7. To what extent do you feel *active* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

8. To what extent do you feel *upset* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

9. To what extent do you feel *attentive* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

10. To what extent do you feel *hostile* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

11. To what extent do you feel *ashamed* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

12. To what extent do you feel in *physical pain* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

13. To what extent do you feel *upset* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

Page 2

SWB (T3)

14. To what extent do you feel *stressed* at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

15. The next questions refer to your activities just within the past day starting with when you woke up this morning. Check all that apply. During the past day have you...

☐ Been to other rooms of your home besides the room where you sleep?

☐ Been to an area outside your home such as your porch, deck or patio, hallway (of an apartment building) or garage, in your own yard or driveway?

☐ Been to places in your neighborhood, other than your own yard or apartment building?

☐ Been to places outside your neighborhood, but within your town?

☐ Been to places outside your town?

16. To what extent do you feel happy at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

17. To what extent do you feel sad at the present moment?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

18. When answering the following question, consider the entire day from the time you woke up until the time you plan to go to bed.
How much time did you spend engaging in social activity today?
(Round to the nearest half hour. Example: One hour = "1", One and a half hours = "1.5")

Hours ____________________

SWB (T3)

19. When answering the following question, consider the entire day from the time you woke up until the time you plan to go to bed.
How much time did you spend engaging in physical activity today?
(Round to the nearest half hour. Example: one hour = "1", one and a half hours = "1.5")

Hours

20. To what extent was today *a typical weekday* for you?

○ Not at all ○ A little ○ Moderately ○ Quite a bit ○ Extremely

APPENDIX F: UNIQUE FINAL ASSESSMENTS

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Survey Feedback

Please use the space provided to answer the following questions.

2. What types of activities did you have in mind when you were filling out how many hours you spent engaging in physical activity each night?

3. What types of activities did you have in mind when you were filling out how many hours you spent engaging in social activity each night?

4. Please list any significant events or life changes that may have impacted your responses to surveys this past month, but do not necessarily happen in a typical month for you (change in living arrangement, family birth, onset of injury/illness, death of a friend or family member, vacation, etc.).

5. Did your participation in this study influence your emotions in any way? If so, how?

6. Are there any questions we did not ask in this research study that you think would have been informative? If so, please describe them below.

7. Please feel free to provide any other comments or concerns you had about the surveys in general. We count on your feedback to improve our research studies!

APPENDIX G: FULL DAILY AGGREGATE MODELS

	Daily PA			Daily NA		
Parameter	Estimate	SE	*p*-value	Estimate	SE	*p*-value
Fixed Effects						
Intercept	3.132	0.361	**<.0001**	0.056	0.031	0.0811
Pain	-0.017	0.035	0.6353	-0.001	0.005	0.8021
Stress	0.040	0.037	0.2838	0.050	0.006	**<.0001**
Sleep	0.019	0.014	0.1747	0.000	0.002	0.8906
Subjective Health	0.266	0.029	**<.0001**	-0.001	0.004	0.8067
Social Activity	-0.002	0.006	0.6580	-0.000	0.001	0.7852
Physical Activity	0.008	0.007	0.2069	-0.000	0.001	0.3304
Life Space	0.037	0.015	**0.0149**	-0.002	0.001	0.1102
Objective Health (Group)	-0.010	0.143	0.9425	-0.006	0.012	0.5827
Variance Components						
Intercept Variance	0.375	0.072	**<.0001**	0.003	0.000	**<.0001**
Pain	0.024	0.012	**0.0207**	0.001	0.000	**0.0029**
Stress	0.029	0.016	**0.0321**	0.001	0.000	**0.0014**
Sleep	0.000	0.002	0.4530	0.000	0.000	0.0895
Subjective Health	0.011	0.008	0.0831	0.000	0.000	**0.0127**
Life Space	0.005	0.003	**0.0373**	0.000	0.000	0.0994
Slope-Intercept Covariance						
Pain	-0.034	0.022	0.1298	-0.000	0.000	0.1402
Stress	-0.02528	0.037	0.4901	0.001	0.000	0.0617
Sleep	0.00435	0.012	0.7176	0.000	0.000	0.1668
Subjective Health	0.01412	0.024	0.5492	0.000	0.000	0.8054
Life Space	-0.01522	0.009	0.0980	-0.000	0.000	0.0885
Residual	0.07101	0.004	**<.0001**	0.001	0.000	**<.0001**
Model Fit (-2RLL)						
Null	928.2			-4125.5		
Random	581.8			-3980.5		

APPENDIX H: FIXED VS RANDOM FIT STATISTICS AND EFFECT SIZES

	Positive Affect				Negative Affect			
Models	-2RLL	Δ-2RLL	σ^2	Within Subjects *R*-squared	-2RLL	Δ-2RLL	σ^2	Within Subjects *R*-squared
Null	928.2		0.104		-4125.5		0.001241	
Full Models								
Fixed Effects	662.8	265.4	0.08307	0.20	-3880.9	-244.6	0.000875	0.29
Random Effects	581.8	81	0.07101	0.32	-3980.5	99.6	0.000684	0.45
Isolated Models								
Pain								
Fixed Effects	919.2	9	0.1027	0.01	-4124.4	-1.1	0.001232	0.01
Random Effects	875.8	43.4	0.09569	0.08	-4131	6.6	0.001199	0.03
Stress								
Fixed Effects	929.5	-1.3	0.1037	0.00	-4437.4	311.9	0.000915	0.26
Random Effects	912	17.5	0.09995	0.04	-4479.6	42.2	0.000841	0.32
Sleep Quality								
Fixed Effects	868.3	59.9	0.09973	0.04	-3983.8	-141.7	0.001258	-0.01
Random Effects	859.8	8.5	0.09663	0.07	-3984.2	0.4	0.001258	-0.01
Subjective Health								
Fixed Effects	756.7	171.5	0.09085	0.13	-3999.5	-126	0.001163	0.06
Random Effects	745.5	11.2	0.08817	0.15	-4010	10.5	0.001109	0.11
Physical Activity								
Fixed Effects	834.9	93.3	0.0985	0.05	834.9	-4960.4	0.001184	0.05
Random Effects	833.2	1.7	0.09742	0.06	833.2	1.7	0.001175	0.05
Social Activity								
Fixed Effects	847.5	80.7	0.09837	0.05	847.5	-4973	0.0012	0.03
Random Effects	843.1	4.4	0.09631	0.07	843.1	4.4	0.001181	0.05
Life Space								
Fixed Effects	856	72.2	0.09897	0.05	-3990.1	-135.4	0.001209	0.03
Random Effects	830.1	25.9	0.09229	0.11	-3991.4	1.3	0.001209	0.03

APPENDIX I: CORRELATION MATRIX FOR PRIMARY STUDY VARIABLES

Factor	1	2	3	4	5	6	7	8	9
1. PA	-	0.01	-0.05	-0.03	0.06	0.15	0.02	0.01	0.03
2. NA		-	0.00	**0.22**	-0.04	-0.03	-0.01	-0.01	-0.01
3. Pain			-	**0.08**	**-.10**	**-0.28**	-0.01	**0.08**	-0.04
4. Stress				-	**-0.13**	**-0.16**	0.01	0.02	0.05
5. Sleep					-	**0.22**	**0.08**	0.06	0.01
6. Subjective Health						-	0.03	**-0.08**	0.06
7. Social Activity							-	**0.23**	**0.38**
8. Physical Activity								-	**0.14**
9. Life Space									-

APPENDIX J: DAILY AGGREGATE VS. OBSERVATION MODEL DESCRIPTION

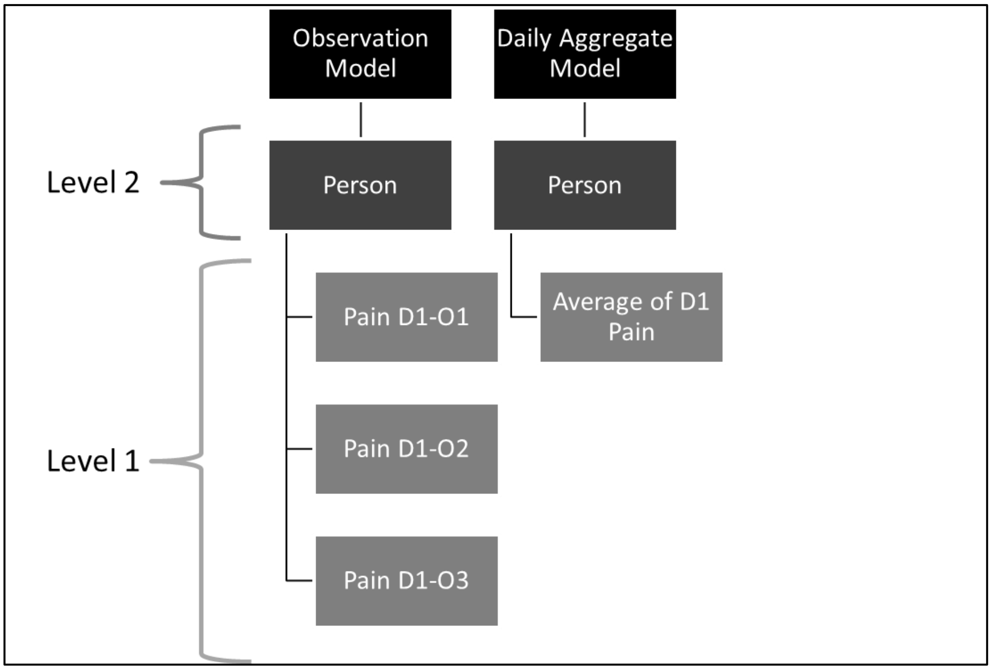

Diagram of observation models vs. daily aggregate models using pain as an example. In the daily aggregate models, scores for items that were asked 3x per day such as pain were averaged for each day, resulting in 20 pain scores at level 1 of the model for each person (level 2). This was done so predictors that were assessed only once per day (life space, physical activity, subjective health, sleep, and social activity) could be included at level 1 of analysis. In the following analyses of the observation models, 3x per day scores were *not* aggregated, so a person with a perfect response rate would have 60 total pain scores (and 60 total Positive Affect and Negative Affect scores). Pain D1-O1 represents the first observation (O1) on the first day (D1), Pain D1-O2 represents the second observation (O2) on the first day (D1), and so on. Because pain and stress were the only predictors that were assessed 3x per day, these are the only predictors that can be analyzed in the observation model analyses. These can be compared to the daily aggregate models on a surface level in terms of which effects were significant, but not in terms of variance explained or of model fit.

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