ABSTRACT

WEATHERBEE, SARAH ROSE. Assessing the Between- and Within-Person Relationships between Pain and Cognitive Performance in Older Adults. (Under the direction of Jason C. Allaire, Ph.D.)

The current study was part of a larger study where the overarching purpose was to design a daily measure of everyday cognitive performance. The current investigation examined the extent to which self-reported pain was related to cognitive performance in a sample of 148 community dwelling older adults (*M* = 73 years old, *SD* = 6.84). A multidimensional battery was used to assess socio-demographics, physical health (self-reported pain and physical health), mental health (negative affect, life-event stress, and daily stress), and cognitive functioning short-term memory, processing speed, inductive reasoning, and working memory) at pretest and over 8 occasions. The direct relationship between self-reported pain and cognition was examined as well as potential moderators and mediators of the pain-cognition relationship at the between- and within-person levels. At the between-person level, self-reported pain was found to be significantly related to processing speed, where high pain was associated with slower reaction time. At the within-person level, self-reported pain was significantly related to working memory, where on days when self-reported pain was higher than an individual's average, their working memory performance suffered. Within-person self-reported Pain X Age interactions were found for short-term memory, processing speed, and working memory. Additionally, negative affect and stress were found to moderate the pain-cognition relationship. The strength of the pain-cognition relationship is best understood by examining moderating factors such as age, stress, and negative affect. Furthermore, significant interactions at the within-person level suggest that the pain-cognition relationship is dynamic and should not be assessed at only one time point.

Assessing the Between- and Within-Person Relationships between Pain and Cognitive Performance in Older Adults

by
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BIOGRAPHY

I completed my undergraduate work at the State University of New York at Cortland in 2004 with a Bachelor of Science degree in Psychology. In the year 2004 I enrolled in a combined M.S. and Ph.D. program in developmental psychology at North Carolina State University in Raleigh under the direction of Dr. Jason C. Allaire. The research for my master's program focused on the use of an expressive writing technique to improve cognitive functioning in older adults. In December, 2006, I earned my Masters of Science degree in Developmental Psychology. In April, 2008, I successfully passed my preliminary exam.

Presently, I am completing my graduate studies in the doctoral program at North Carolina State University. My current research interests primarily focus on the following four topics: (1) the extent to which cognitive and everyday functioning can be improved through the use of interventions; (2) real-world functioning of older adults, with an emphasis on the relationship between basic cognitive abilities, everyday cognition, and everyday functioning; (3) factors related to short-term intraindividual variability in cognitive and everyday functioning; (4) the extent to which self-reported pain is related to cognitive functioning and the potential moderating and mediating factors of this relationship. With these research interests in mind, I have presented several abstracts to national conferences. In addition, some of these research findings have been published in scientific journals (i.e. Weatherbee & Allaire, 2008; Weatherbee, Gamaldo, & Allaire, in press).

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Last but certainly not least, I would like to thank my husband Timothy James Kennedy, my parents Timothy and Deborah Weatherbee, as well as my friends Rebecca Stelter and Tara Queen (fellow graduate students) for their encouragement and assistance during the entire process. They all have been great during the writing of my dissertation, especially when I needed the extra support.

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Introduction

Self-reported pain is common among older adults and is related to various negative outcomes (Horgas & Yoon, 2008; Nezu, Nezu, & Jain, 2008; Onder, Cesari, Russo, Zamboni, Bernabei, & Landi, 2006; Tennen, Affleck, & Zautra, 2006). For example, researchers have found pain to be related to worse physical functioning (Onder et al., 2006), higher levels of depression (Tennen et al., 2006), greater stress (Nezu et al., 2008), lower well-being (Mayer & Baltes, 1996), and poorer cognitive performance (Karp et al., 2006). However, there are inconsistencies across studies in the extent to which pain influences cognitive performance (Brown, Glass, & Park, 2002; Karp et al., 2006; Grisart, van der Linden, & Bastin, 2007; Oosterman, de Vries, Dijkerman, de Haan, & Scherder, 2009). These inconsistencies may be due to a number of factors, such as collecting data from chronic pain samples rather than community-dwelling older adults, the age of the sample (e.g. middle-adults, old adults, or older-old adults), and the type of cognitive ability assessed (e.g. complex fluid, simple/basic, and/or crystallized).

The current research on pain and cognition is focused on further exploration of the constructs identified by between-person designs through the use of within-person designs (Hultsch, Strauss, Hunter, & MacDonald, 2008; Sliwinski & Buschke, 2004). Utilizing a within-person design might help to further elucidate the pain-cognition relationship by investigating both the between- and within-person associations among self-reported pain and cognitive performance.

The overarching aim of the current study was to examine the extent to which the report of pain was related to cognitive functioning in a sample of older adults. Furthermore, the study examined whether potential moderators and mediators (e.g. age, stress, and negative affect) influenced the pain-cognition relationship. Finally, the investigation explored the pain-cognition relationship by using both between- (e.g. pretest or baseline assessment) and within-person analyses (e.g. eight daily occasions of assessment). Such a method allows for the examination of the effects of fluctuations in daily self-reported pain.

Review of the Literature

Cognitive Functioning in Older Adults

Individual Differences in Cognitive Performance

General age-related declines are found in cognitive performance, particularly in abilities such as processing speed, working memory, short-term memory, and inductive reasoning (MacDonald, Dixon, Cohen, & Hazlitt, 2004; McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002). Between-person differences in the rate of decline have also been found across multiple cognitive domains (Bugg, Zook, Delosh, Davalos, & Davis, 2006; Schaie, 1996; Singer, Verhaeghen, Ghisletta, Lindenberger, & Baltes, 2003; Schaie, Willis, & Caskie, 2004). Cognitive aging researchers suggest that the between-person differences may be a result of contextual factors, such as health (Brady, Spiro, & Gaziano, 2005; Hultsch, Hammer, & Small, 1993). One aspect of health that might be related to cognition but has received little attention is the construct of pain, which is common in older adults (Horgas &

Yoon, 2008). Consequently, the goal of the current study was to identify the extent to which self-reported pain is related to individual differences in performance.

Pain in Old Age

Description of Pain

According to the International Association for the Study of Pain (IASP, 2009), pain is defined as, "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage." This definition emphasizes that both neurological and psychological components are necessary for the experience of pain. In other words, a stimulus that triggers a response similar to pain but does not elicit an unpleasant experience should not be considered pain. Consequently, pain is a subjective experience and as such is influenced by individual differences in neurological and psychological functioning, the extent to which they report the experience of pain, and the degree to which they choose to manage the pain.

Pain is typically divided into two categories based on duration. Acute pain is a sudden experience of pain that typically lasts no more than one day (Yehuda & Carasso, 1997), and generally goes away once the source of pain is identified and treated (Gagliese & Melzack, 1997a). Dental work, headaches, broken bones, and skin burns are examples of sources of acute pain. Chronic pain persists even after the injury or source of the pain has been treated (Gagliese & Melzack, 1997a; Horgas & Yoon, 2008). This type of pain can last months, or even years after the initial causes are treated. Cancer-related pain, migraines, lower back pain, arthritis, and nerve damage, or "neurogenic pain" are all examples of chronic pain.

The examination of age-related differences in the type of pain reported has yielded disparate results. Some studies have found that older adults report less acute pain (Gagliese & Melzack, 1997a; Roy, 1995) and more chronic pain relative to younger- and middle-aged adults (Gagliese & Melzack, 1997b; Thomas, Peat, Harris, Wilkie, & Croft, 2004). Other studies have not found significant age-related differences in the number of self-reported acute and chronic pain complaints (Thomas et al., 2004). Similarly, results from studies examining age differences in the overall frequency of self-reported pain have been mixed. Studies have reported that the frequency can remain relatively stable throughout the lifespan (Horgas & Yoon, 2008), can increase with age (Harkins & Price, 1992), or even decline with age (Lachapelle & Hadjistavropoulos, 2005). Interestingly, findings have been more consistent when examining age-related differences in self-reported pain within older adults (e.g. 60-90+ year olds). More specifically, oldest-old adults tend to report less pain when compared to younger-old adults (Helme & Gibson, 2001; Mobily, Herr, Clark, & Wallace, 1994; Roy & Thomas, 1988; Zyczkowska, Szczerbinska, Jantzi, & Hirdes, 2007). In these groups, a relationship has been shown between self-reported pain and various negative outcomes (Brown et al., 2002; Onder et al., 2006; Leong, Farrell, Helme, & Gibson, 2007; Tunks, Cook, & Weir, 2008).

Outcomes Associated with Pain

It is estimated that between 70-85% of community dwelling older adults experience health-related conditions (e.g. cancer, fibromyalgia, osteoarthritis) that predispose them to persistent pain (Horgas & Yoon, 1998; Karp et al., 2006). The self-report of pain is associated with increases in stress and anxiety, decreased energy, limited mobility, and sleep difficulties (Leong et al., 2007). Onder and colleagues (2006) examined the relationship between pain and physical functioning (e.g. walking speed, balance, and grip strength) in 273 individuals aged 80 years or older. Participants who reported pain every day for seven days had poorer physical functioning compared to those who did not report daily pain. Additionally, older adults who reported persistent pain typically had greater anxiety and depression compared to individuals with very few or no complaints of pain (Brown et al., 2002; Leong et al., 2007; Tunks et al., 2008). One study (Leong et al., 2007) examined 538 individuals from a pain clinic who were over the age of 65 years (*mean* = 76 years old) and found that approximately 66% of the participants were identified as having high anxiety and over 56% were identified as having mild, or severe depressive symptoms. In addition, higher levels of reported pain intensity were positively related to both depression and anxiety.

With regard to the study of cognition, research examining the extent to which pain is related to performance in younger- and middle-aged adults found that pain is related to poorer performance on measures that assess executive functioning (Karp et al., 2006), working memory (Eccleston, 1995), and short-term memory (Grisart et al., 2007). Research on the relationship between pain and cognition specifically in older adult samples is relatively limited; it has only been examined in older adults in clinical treatment programs or living in nursing homes. For example, Karp and colleagues (2006) examined the cognitive functioning of older adults (*mean age* = 76 years old) who were enrolled in a clinical treatment program for pain management. Poorer performance on an executive functioning measure was related to self-reported high pain severity, while no significant relationships were found between pain and processing speed or short-term memory. In a sample of older adults (*mean age* = 84 years old) living in a nursing home and identified as having at least one chronic pain condition, Oosterman and colleagues (2009) found that poorer executive functioning was associated with the self-reported "unpleasantness" of pain. Weiner and colleagues (2006) compared older adults (*mean age* = 73 years; *range* = 65-84 years old) who were diagnosed with chronic lower back pain to individuals who had reported no more than one weekly, low-intensity pain complaint. Chronic pain patients performed significantly worse than the no-pain older adults on measures of executive functioning, immediate memory, and delayed memory tasks. No significant differences were found on measures of attention, visual-spatial ability, or verbal intelligence.

Given that these studies were conducted in clinical samples of older adults experiencing chronic pain, the results may not be generalizable to a community-dwelling, older adult population. The current study is possibly one of the first to explore the potentially negative effect of pain in a non-clinical sample of community-dwelling older adults. Further, the aforementioned studies generally found that higher-order fluid abilities (e.g. executive functioning, working memory, short-term memory) were most affected by self-reported pain, whereas lower-order (e.g. processing speed) and crystallized abilities (e.g. verbal intelligence) were the least, if at all, affected by the report of pain. Thus it could be the case that the complex, fluid abilities which require a greater amount of cognitive resources will be influenced the most by the self-reported pain compared to simple and/or crystallized abilities that require fewer resources. Therefore, the current study examined the self-report of pain and its relationship with performance across multiple domains of cognitive functioning (e.g. short-term memory, processing speed, working memory, inductive reasoning, and verbal ability).

Explanations for the Pain-Cognition Relationship

Age as a Proxy

Although there is little empirical research on the pain-cognition relationship within "healthy" older adult populations, there are some explanations as to why pain might be related to cognitive performance. Existing research suggests that decrements in inhibitory functioning may make it difficult for individuals to ignore intrusive, irrelevant information (Hartman & Hasher, 1991; Hasher, Zacks, & May, 1999) and focus on the task at hand (e.g. completing cognitive assessments). Previous research has suggested that the experience of pain can cause intrusive thoughts which use up available resources if they are not effectively ignored (Oosterman et al., 2009). It is postulated that both pain and cognition compete for available resources as a function of effectiveness of the inhibitory process (Hart, Wade, & Martelli, 2003; Karp et al., 2006; Oosterman, et al., 2009). Therefore, intrusive thoughts relating to the experience of pain may result in a negative relationship between pain and cognitive functioning. Unfortunately, intrusive thoughts relating to pain were not assessed in the current study; the explanation is offered to give a rationale as to why self-reported pain may impact cognitive performance. Typically, cognitive tasks that are related to complex fluid abilities (e.g. working memory, short-term memory, and inductive reasoning) are most affected by changes in inhibitory processes (Bowles & Salthouse, 2003; Zacks, Hasher, & Li, 2000). Age-related declines in the inhibitory process demonstrate that older adults tend to have worse inhibitory control compared to younger and middle-aged adults (Hasher et al., 1999). Thus, it is hypothesized that the pain-cognition relationship might be moderated by age, where age is treated as a proxy for inhibitory control. Furthermore, the age-related decrements in the inhibitory mechanism may lead to an increase in interference from the self-reported pain which may result in poor performance. More specifically, the old-old adults may have an increased difficulty in ignoring the pain in order to focus on the cognitive task at hand, compared to the younger and middle-aged adults who may have more efficient inhibitory processes that allow them to effectively ignore the pain. Furthermore, it is hypothesized that the pain-cognition relationship will be strongest in complex cognitive abilities largely reliant on the inhibitory processes such as working memory, inductive reasoning, and short-term memory.

A second explanation of the pain-cognition relationship involves an individual's threshold for pain, which may account for the extent to which pain is related to cognitive performance. More specifically, individuals who have a higher pain threshold may report fewer, or less intense pain complaints compared to those with a lower threshold of pain; it is hypothesized that there are age differences in the threshold for pain, such that older adults have higher thresholds compared to younger adults (Pickering, Jourdan, Eschalier, &, Dubray, 2002; Quiton, Roys, Zhuo, Keaser, Gullapalli, & Greenspan, 2007). Pickering and colleagues (2002) examined both the idea that there are age differences in pain thresholds, and the extent to which an individual's threshold is related to cognitive performance (e.g. MMSE). The induction of pressure and heat were used to assess each participant's threshold and when the induced stimuli became too much for the participant to handle, they were instructed to press a button indicating their threshold had been reached. They found that older adults (*mean age* = 74 years old) had significantly higher pain thresholds compared to the younger adults (*mean age* = 22 years old). In addition they found a significant correlation between cognitive performance and pain thresholds, such that higher thresholds of pain were related to higher cognitive functioning. Due to the fact that older adults have higher pain thresholds compared to younger and middle-aged adults, and the relationship that exists between pain threshold and cognitive performance, it could be argued that the pain-cognition relationship is not as strong in older adults. Moreover, research has demonstrated that pain is reported less in old-old adults compared to young-old adults, so it could be argued that the threshold of pain increases in old adulthood (Yehuda & Carasso, 1997; Zyczkowska et al., 2007).

The provided explanations are two competing hypotheses detailing how age could potentially moderate the pain-cognition relationship. The current study postulates that there will be an age-related decrease in the relationship between pain and cognition due to an increase in an individual's threshold for pain. However, if a significant relationship between pain and cognition is found in the younger-old adults, the intrusiveness of the thoughts related to pain may still use up resources that are needed to complete the cognitive tasks, thus it is further hypothesized that the relationship between cognition and self-reported pain will most likely be found within the complex cognitive abilities (e.g. working memory, inductive reasoning, and short-term memory).

Stress and Depression/Negative Affect

Another explanation posits that variables such as stress (Chapman & Gavrin, 1999) and depression (Kewman, Vaishampayan, Zald, & Han, 1991; Brown et al., 2002) mediate or moderate the relationship. Research has shown that the self-report of pain is related to feelings of a decreased quality of life (Jakobsson, Hallberg, & Westergren, 2004), changes in perceived control (Gibson & Helme, 2000), poor coping mechanisms (Conner et al., 2006), decreased physical mobility (Leong et al., 2007), and a decrease in the number of social interactions (Zautra, Hamilton, & Yocum, 2000). Such negative outcomes have also been found to be associated with stress (Aldwin, 1994) and/or depression (Strawbridge, Deleger, Roberts, & Kaplan, 2002).

Similarly, research has found a relationship between stress, depression, and cognitive functioning in older adults. Individuals with more stress and/or depression have worse cognitive functioning compared to those with little, or no stress and/or depression (Baune, Suslow, Engelien, Arlot, & Berger, 2006; Christensen, Griffiths, MacKinnon, & Jacomb, 1997; Klein & Boals, 2001; Neupert, Almeida, Mroczek, & Spiro, 2006; Sliwinski, Smith, Hofer, & Stawski, 2006). It could be argued that the negative outcomes associated with pain are more proximally due to stress and/or depression. Therefore, it would be beneficial to examine the relationship between self-reported pain and stress/depression, and the extent to which stress and/or depression influence cognitive functioning. The following sections describe empirical research that has found significant relationships between pain and cognition, as well as pain, stress, and depression.

Depression/Negative Affect

As previously stated, significant relationships have been found between depression and cognition (Baune et al., 2006; Christensen et al., 1997) and depression and pain (Buys, Roberto, Miller, & Blieszner, 2008; Mossey, Gallagher, & Tirumalasetti, 2000; Patil, Johnson, & Lichtenberg, 2008). For instance, previous research has established a significant relationship between depression and pain in that individuals with persistent pain tend to report depression more frequently, and depressed individuals are more likely to report feelings of pain (Brown et al., 2002; Buys et al., 2008; Gagliese & Melzack, 1997a; Leong et al., 2007; Mossey et al., 2000; Patil et al., 2008).

One explanation for the pain-depression relationship in that the experience of pain can result in various negative outcomes that increase the susceptibility to depressive symptoms (Parmelee, Katz, & Lawton, 1991). More specifically, research suggests that the experience of pain, especially chronic pain, can hinder individuals from completing normal day-to-day activities which results in a decline in independence and decreased feelings of control. Empirical evidence has shown that individuals who report their pain as debilitating are more likely to also report increased feelings of helplessness, decreased feelings of internal control, and/or decreased number of social interactions (Skevington, 1983). Each of these outcomes has been shown to be highly correlated with the experience of depression or depressive-like symptoms. Given these relationships, it is hypothesized that as the experience of pain increases, individuals are more likely to encounter negative outcomes that in turn increase the propensity to experience depressive symptoms.

Depression has also been found to be related to cognitive functioning in that individuals identified as experiencing depressive symptoms tend to perform more poorly on cognitive ability tests compared to those without depressive symptoms (Baune et al., 2006; Christensen et al., 1997). In particular, performance on memory tasks has been found to be significantly worse in individuals with depressive symptoms compared to non-depressive individuals (Lichtenberg, Ross, Millis, & Manning, 1995; Scherder, et al., 2008). Given these relationships between pain and depression and pain and cognition, it is hypothesized that negative affect will mediate the pain-cognition relationship. More specifically, the relationship between self-reported pain and cognition will become non-significant once the model accounts for the intervening effect of depressive symptoms. This mediating relationship has been found in previous research (Brown et al., 2002). Therefore, the current study will attempt to expand on these findings by examining the relationship among a community-dwelling sample of older adults at both the between- and within-person level.

Although the Center for Epidemiological Studies - Depression Scale (CES-D; Radloff, 1977) was used in the current study, it was not used across the eight daily occasions. Recall that a major aim of the current investigation was to examine the between- and within-person relationships among self-reported pain and cognition, therefore the CES-D, which was only assessed at pretest, would not be a useful assessment. Previous research has shown that depression and negative affect are highly correlated (Clark, Watson, & Mineka, 1994; Hu & Gruber, 2008; McQuillan et al., 2003; Reich, Johnson, Zautra, & Davis, 2006). Fortunately, the current study assessed negative affect using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). In fact, McQuillan and colleagues (2003) found that PANAS-Negative Affect was significantly and positively correlated with depression/depressive symptoms ($r = .79$, $p < .05$), which were assessed using the CES-D. Since previous studies had shown that the negative affect scale on the PANAS was highly correlated with depression ratings on the CES-D, the current study used PANAS-Negative Affect as a proxy for daily depressive symptoms. Consequently, the PANAS negative affect composite score was used to obtain an approximate assessment of daily depressive symptoms. It was thus hypothesized that the relationship between self-reported pain and cognition will be explained by the intervening variable, negative affect. Since the cognition-depression relationship was found for memory; it is additionally hypothesized that the strongest mediating relationships would be found in the tests that assess short-term memory (e.g. AVLT).

Stress

Unlike depression, few studies have examined whether stress mediates or moderates the pain-cognition relationship. However, there is some research indicating that interpersonal stressors are related to self reported pain (Affleck, Tennen, Urrows, & Higgins; Zautra & Smith, 2001), and life event stress and daily stressors are related to cognitive functioning (Klein & Boals, 2001; Neupert et al., 2006; Sliwinski et al., 2006). Specifically, a positive association between stress and pain has been found such that more stress is related to greater self-reported pain (Kennedy, Kassab, Gilkey, Linnel, & Morris, 2008; Lau, Hui, & Lam, 1996; Nezu et al., 2008). In addition, significant relationships between cognition and stress have been widely demonstrated within the cognitive aging literature where higher levels of stress are related to poorer cognitive functioning in older adults, particularly on measures that demand attentional resources (e.g. working memory) (Berchtold, 2008; Neupert, Stawski, & Almeida, 2008; Sliwinski et al., 2006; Stawski, Sliwinski, & Smyth, 2006).

As previously discussed, the experience of pain has been shown to interfere with an individual's level of cognitive functioning, which may be a result of intrusive thoughts relating to the pain (Oosterman, et al. 2009; Valet, et al., 2004). One possible explanation as to why stress could be related to cognition functioning is that the experience of stressors can potentially lead to an increase in the level of stress-related intrusive thoughts (Klein &

Barnes, 1994). Consequently the stressor-related intrusive thoughts may use up available resources and impede an individual's ability to process information and complete cognitive tasks. Given these relationships, it was proposed that there would be a relationship between self-reported pain, stress, and cognition, where the combined interference effects of stress and pain would occupy the available resources needed to complete the cognitive tasks. Thus, it was hypothesized that stress will moderate the relationship between self-reported pain and cognition, where the strongest pain-cognition relationship would be found in individuals who report high pain and high stress compared to individuals who report low pain and low stress. Furthermore, since working memory performance was found to be strongly related to both self-reported pain and the experience of stressors, it was hypothesized that the moderating relationship would be most pronounced in the measures that assess working memory.

Importance of Examining Within-Person Coupling Relationships

Most studies examining the pain-cognition relationship have employed traditional cross-sectional and longitudinal designs. Such approaches ignore daily variations in pain and the impact such variations might have on older adults' cognition. Some studies, particularly those by Zautra and colleagues, have examined the within-person variability in pain and found that pain does in fact fluctuate within each day and across multiple days (Davis, Affleck, Zautra, & Tennen, 2006; Finan, Zautra, & Tennen, 2008; Kratz, Davis, & Zautra, 2007; Zautra, Smith, Afflec, & Tennen, 2001). For instance, Affleck and colleagues (1991) assessed daily pain ratings in women with rheumatoid arthritis over the course of 75 days.

Participants were instructed to report their daily joint pain ratings on a scale of 0 (no pain or tenderness) to 3 (severe pain or tenderness). They found significant individual differences in the magnitude of daily pain fluctuation. In the ADAPT study (Arthritis, Diet, and Activity Promotion Trial), older adults (*mean age* = 69 years old) were instructed to fill out questionnaires regarding their current level of pain every time they were notified by a pager, which occurred up to six times a day for six days (Focht, Ewing, Gauvin, & Rejeski, 2002). The Borg scale of pain was used, which asked participants to rate their current pain on a scale ranging from 0 (no pain at all) to 10 (extremely strong pain). Although average pain was low (*mean* = 1.60), significant between-person (68%) and within-person (32%) variability was found. Roelofs and colleagues (2004) implemented a daily diary "beep" study in which participants filled out an assessment battery each time their designated palm pilots prompted them to do so. Participants were "beeped" eight times a day for seven consecutive days, totaling 56 occasions. Pain was assessed by asking participants whether or not they were feeling pain at the exact moment. Significant variability was found such that 53% of the variance was found between-persons and 47% was found within-persons.

In addition, cognitive aging researchers have long noted the importance of utilizing short-term within-person designs (Martin & Hofer, 2004; Nesselroade, 2004; Nesselroade & Ford, 1985). Previous studies that have implemented such designs have found significant between- and within-person variability across various cognitive domains (Allaire & Marsiske, 2005; Gamaldo, Weatherbee, & Allaire, 2008; Hultsch, MacDonald, & Dixon, 2002; Ram, Rabbitt, Stollery & Nesselroade, 2005; Salthouse, Nesselroade, & Berish, 2006).

For example, Gamaldo and colleagues (2008) examined variability in performance on inductive reasoning, short-term memory, and processing speed tests over 120 occasions. They found significant variability on the tests such that up to 46% of total variance explained was within-person and up to 80% was between-person. Furthermore, researchers have noted the importance of examining covariates associated with the within-person fluctuation in cognitive performance and the extent to which the variables are associated with one another over a short period of time. This is known as a coupling effect, which is defined as the examination of how two variables possibly move and change together over time within an individual. Coupling effects have been found between daily cognition and constructs such as blood pressure (Gamaldo et al., 2008), stress (Neupert et al., 2006), vision (Weatherbee, Gamaldo, & Allaire, in press), and emotion (Chow, Hamagami, & Nesselroade, 2007). For example, Gamaldo and colleagues (2008) found that among individuals who were classified as hypertensive, cognitive performance suffered on those occasions when their blood pressure was significantly higher than their mean.

Given that day-to-day fluctuations in pain (Conner et al., 2006; Davis et al., 2006) and cognition (Allaire & Marsiske, 2005; Hultsch et al., 2002) have been found, and that pain and cognition are associated with one another at the between-person level (Harman & Ruyak, 2005; Karp et al., 2006), it was hypothesized that a significant within-person relationship would also be found between fluctuation in self-reported pain and fluctuation in cognitive performance. More specifically, on occasions when self-reported pain is higher than average, cognition would be worse. The within-person, or coupling, relationship between pain and cognition might provide further insight as to why there are inconsistencies in the pain-cognition literature. It could be the case that the previously used between-person designs were unable to capture the dynamic relationship between interindividual differences in intraindividual change.

A few studies have examined the coupling relationship between pain and constructs such as physical functioning (Parrish, Zautra, & Davis, 2008), grip strength (Onder et al., 2006), and sleep (Lederman, Linder, Greenwood, & Philip, 2008). For example, Parrish et al. (2008) implemented a 30 day daily diary study in women (*mean* age = 52 years old) diagnosed with rheumatoid arthritis, osteoarthritis, and/or fibromyalgia. They found that high average pain and increases in daily pain were associated with poorer physical functioning. Connor and colleagues (2006) implemented a daily diary study in order to examine the associations of pain, pain coping strategies and appraisals, and affect in men and women (*mean age* = 56 years; *range* = 23 – 86 years) identified as having rheumatoid arthritis over the course of 30 days. Daily pain was associated with affect, as well as pain coping strategies and appraisals. In fact, they found that an increase in daily pain was associated with increases in employed coping strategies, decreased quality of coping appraisals, and worse mood. To date, no study has examined whether there is a coupling relationship between pain and cognition. Consequently, the current investigation was possibly one of the first to examine the dynamic relationship in a sample of healthy, community-dwelling older adults.

Potential Mediating and Moderating Relationships at the Within-person Level

As previously mentioned, the current study examined the potential mediating and moderating relationships on self-reported pain and cognition with respect to the between-person level. Furthermore, these relationships were also examined at the within-person level to better understand the nature of the relationship. Each of the variables (e.g. stress, negative affect, and age), could potentially impact the self-reported pain-cognition relationship at the within-person level.

Significant within-person variability in daily stress (Almeida, Neupert, Banks, & Serido, 2005; Mroczek & Almeida, 2004; Stawski et al., 2008) as well as within-person relationships between stress and pain (Affleck et al., 1997) and stress and cognition have been found (Neupert et al., 2006; Sliwinski et al., 2006). For example, a significant within-person association between stress and pain was found in participants (*mean age* = 53 years old) who completed a daily stressors questionnaire (Daily Life Experience Checklist), and a pain assessment every two weeks over a ten week period (Affleck et al., 1997). On days when participants reported more stressors they also had higher reports of pain, compared to days with fewer reported stressors. In terms of stress and cognition, Sliwinski and colleagues (2006) found significant within-person fluctuations in daily stress, over six occasions, in both younger and older adults. Furthermore, it was found that on days in which individuals reported stress, their performance on a working memory task suffered. A daily diary study conducted by Neupert et al. (2006), examined the relationship between daily stressors and memory failures in older adults for eight days. Overall, they found a significant within-person relationship between stress and memory failures such that on days when an individual reported increased stressors, especially interpersonal stressors, they were significantly more likely to report memory failures on that same day. Additionally, daily stress has been shown to be related to increased pain on that day (Cathcart & Pritchard, 2008; Hertig, Cain, Jarrett, Burr, & Heitkemper, 2007). Due to the fact that previous research has established that a relationship exists among stress, pain, and cognition at the between-person level, and coupling relationships have been found between stress and cognition and stress and pain, the current study extended these findings by examining whether stress moderated the within-person coupling of self-reported pain and cognition. As previously stated, the rationale for this link is that, the presence of pain and stress can cause intrusive thoughts, these intrusions are postulated to use up available resources, which would in turn limit the resources needed to complete cognitive tasks; therefore performance on these tasks will suffer. Thus, it was hypothesized that the relationship between self-reported pain and cognitive performance would be strongest on days when stressors occurred and that performance on the short-term memory and working memory test would be most affected by the relationship.

The present study also examined the extent to which negative affect mediated the pain-cognition coupling relationship. Significant within-person variability in daily negative affect has been found (McCrae, et al., 2008; Ong & Allaire, 2005). For instance, a significant within-person association between negative affect and pain was found in women with fibromyalgia or osteoarthritis (*mean age* = 55 years old, *range* = 35-72 years) who completed assessments of pain and affect weekly for 10-12 weeks. On assessment days when participants reported more pain they also had higher reports of negative affect compared to days with fewer reported pain symptoms. In terms of negative affect and cognition, Roecke (2006) found significant within-person fluctuations in daily negative affect, over 45 daily occasions, across younger and older adults. Furthermore, it was found that on days when individuals reported higher than average negative affect their cognitive performance was worse compared to days when negative affect was low. Due to the fact that previous research has established that a relationship exists among negative affect, pain, and cognition at the between-person level, and coupling relationships have been found between negative affect and cognition and negative affect and pain, the current study extended these findings by examining whether negative affect mediated the within-person coupling of pain and cognition. It was thus hypothesized that the relationship between self-reported pain and cognition would be explained by the intervening variable, negative affect, and that the strongest mediating relationships would be found in the tests that assess short-term memory (e.g. AVLT).

The pain-cognition coupling relationship was further assessed by examining age as a potential moderator. As previously discussed, the relationship between pain and cognition in older adults is hypothesized to be different depending on age. Therefore this hypothesized relationship was examined at the within-person level to determine whether the daily coupling relationship of self-reported pain and cognition was different depending on age. Given the age-related changes in inhibition, the relationship might be stronger in the old-old adults compared to the young-old adults. Alternatively, because of the hypothesized age differences in pain threshold, it could be the case that the coupling relationship is stronger in the young-old adults and weaker with greater age. Overall, the current study examined both the between-person and coupling relationships among self-reported pain and cognitive performance. Additionally, the study explored the extent to which stress, negative affect, and age mediate or moderate the between- and within-person self-reported pain-cognition relationships. The following section provides a detailed description of the individual aims and hypotheses.

Specific Aims

The following aims are broken down into between-person and within-person analyses. The between-person analyses examined the relationships between self-reported pain and cognition at a single occasion (e.g. pretest), as well as the potential mediators and moderators of this relationship (e.g. negative affect, stress, and age). The within-person analyses examined the coupling relationship between self-reported pain and cognition, as well as potential mediators and moderators of that relationship.

Between-Person Analyses

Aim 1: Examine the extent to which the self-report of pain and age are related to cognitive performance

Aim 1a: Examine the extent to which the self-report of pain is related to cognitive performance

Previous research has shown that pain impacts multiple domains of cognitive functioning (Karp et al., 2006; Oosterman et al., 2009). One explanation for this relationship is the experience of pain can result in intrusive thoughts relating to the pain, which may in turn use up available resources needed to effectively complete cognitive tasks (Hartman & Hasher, 1991; Hasher et al., 1999). In addition, age-related declines in inhibitory functioning may influence the extent to which the intrusive thoughts are effectively ignored. Consequently, tasks that are highly related to the cognitive abilities that require adequate resources may be most affected by the intrusions relating to pain, such as working memory, inductive reasoning, and short-term memory (Zacks et al., 2000). Thus, it was hypothesized that individuals who report more pain will perform worse on the following complex fluid ability tests: N-back, AVLT, and Letter Series. Unfortunately, these explanations for the relationship between self-reported pain and cognition could not be tested in the current study, therefore they are provided solely to offer a hypothesis as to why the relationship exists.

Aim 1b: Examine whether age moderates the relationship between pain and cognitive performance

Regarding the pain-cognition relationship, two age-related hypotheses have been proposed. One states that there are age-related declines in the effectiveness of inhibitory control (Zacks et al., 2000), which may result in an increase in the strength of the pain-cognition relationship in the old-old adults compared to the young-old adults. Alternately, the second hypothesis states that there is an age-related increase in the threshold for pain. Thus, the pain-cognition relationship would not be as strong in the old-old adults as a function of the decrease in the experience of pain (Pickering et al., 2002; Quiton et al., 2007). Given that research has shown that the oldest-old adults report significantly less pain compared to young-old adults (Helme & Gibson, 2001; Mobily et al., 1994), it was hypothesized that the "threshold" hypothesis is the most favorable explanation as to how age would moderate the pain-cognition relationship. Therefore the pain-cognition relationship should be weaker in the old-old participants compared to the young-old participants. Unfortunately, these explanations for the relationship between self-reported pain, age, and cognition could not be tested in the current study, therefore they are provided solely to offer a hypothesis as to why the relationship exists. Since the thoughts related to pain have been postulated to be intrusive for the younger-old adults who experience the pain-related intrusive thoughts, their cognitive performance would be negative affected, particularly for the complex, fluid ability tests which have been found to be associated with the level of inhibitory control (e.g. N-back, AVLT, and Letter Series).

Aim 2: Examine whether negative affect mediates and stress moderates the relationship between pain and cognitive performance

Pain has been shown to be related to the experience of both stress (Kennedy et al., 2008; Lau et al., 2008) and depression (Brown et al., 2002; Gagliese & Melzack, 1997a; Leong et al., 2007). Furthermore, high levels of stress (Berchtold, 2008; Neupert et al., 2008; Sliwinski et al., 2006; Stawski et al., 2006) and depression (Baune et al., 2006; Christensen et al., 1997) have been found to be related to poor cognitive performance. In regards to negative affect, previous research has suggested that as the experience of pain increases, individuals are more likely to encounter negative outcomes that in turn increase the susceptibility to experience depressive symptoms/negative affect (Parmelee et al., 1991).

Given that negative affect is related to cognitive performance (Lichtenberg, et al., 1995; Scherder, et al., 2008), it was further hypothesized that the increase in depressive symptoms/negative affect would lead to poor cognitive performance. Consequently, the current study hypothesized that negative affect would mediate the relationship between self-reported pain and cognition. More specifically, the relationship between self-reported pain and cognition would become non-significant once the model accounted for the intervening effect of depressive symptoms. Since the cognition-depression relationship was found for memory; it was additionally hypothesized that the strongest mediating relationships would be found in the tests that assess short-term memory (e.g. AVLT).

In regards to stress, previous research has indicated that interpersonal stressors are related to self-reported pain (Affleck, et al., 2001), and the experience of stressors are related to cognitive functioning (Klein & Boals, 2001; Neupert et al., 2006; Sliwinski et al., 2006). More specifically, the experience of pain and stress has been shown to interfere with an individual's level of cognitive functioning, where the intruding thoughts relating to pain and/or stress impede on an individual's ability to process information (Klein & Barnes, 1994; Oosterman et al. 2009; Valet et al., 2004). Given these relationships, it was postulated that the combined interference effects of stress and pain would occupy the available resources. Thus, fewer resources would be available for processing cognitive information. Unfortunately, the current study did not assess whether an individual experienced intrusive thoughts relating to the stressful event, therefore the above explanation was offered only to provide a possible explanation as to why the relationship would exit. In general, it was hypothesized stress will moderate the pain-cognition relationship where the strongest pain-cognition relationship will be found in individuals who report high pain and high stress compared to individuals who report low pain and low stress. Furthermore, since working memory performance was found to be strongly related to both self-reported pain and the experience of stressors it was further hypothesized that the proposed moderating relationship would be most pronounced in the measures that assess working memory.

Within-Person Analyses

Aim 3: Determine the amount of within- and between-person variability in self-reported pain

Self-reported pain has been shown to fluctuate from day-to-day (Conner et al., 2006; Davis et al., 2006; Tennen et al., 2006). Given these previous findings, it was hypothesized that significant within-person variability would be found over the eight daily testing occasions. In other words, self-reported pain would fluctuate from day-to-day in a sample of community-dwelling older adults. Additionally, it was hypothesized that significant between person variability would be found, meaning that there would be individual differences in average pain ratings.

Aim 4: Examine the extent to which the within-person self-report of pain and age are related to cognitive performance

Aim 4a: Evaluate the coupling relationship between daily self-reported pain and cognitive performance

Although no research has examined the within-person coupling relationship between self-reported pain and cognition, significant, albeit inconsistent, between-person relationships among pain and cognition have been found (Harman & Ruyak, 2005; Karp et al., 2006; Oosterman et al., 2009). Sliwinski and colleagues state that within-person designs can be used to further explain between-person findings by examining the relationship at an individual level (Sliwinski & Buschke, 2004; Sliwinski et al., 2006). Therefore, by implementing a within-person design a more accurate representation of the pain-cognition relationship might be found. Similar to the Aim 1a, it was hypothesized that a significant, negative coupling relationship would be found for self-reported pain and the complex cognitive tasks (e.g. AVLT, Letter Series, and the N-Back tests); such those on days when pain was high, cognition would suffer.

Aim 4b: Examine whether age moderates the coupling relationship between pain and cognitive performance

In addition, the extent to which age moderated the within-person relationship between pain and cognition was explored. If pain was found to fluctuate from day to day, it was hypothesized that a stronger coupling relationship would exist within the younger-old adults who have a lower threshold for pain. In contrast, the coupling relationship between pain and cognition would not be as strong for the older-old adults; as a result of their higher threshold for pain, they would not experience as much of a fluctuation in daily pain. Similar to Aim 1b, it was further hypothesized that this relationship would be more apparent in the complex cognitive tasks (e.g. AVLT, Letter Series, and the N-Back tests). As previously stated, the explanations for the relationship between self-reported pain, age, and cognition could not be tested in the current study, therefore they are provided solely to offer a hypothesis as to why the relationship may exist.

Aim 5: Examine whether negative affect mediates and stress moderates the coupling relationship between pain and cognitive performance

Further examining the impact stress and negative affect may have on the relationship between self-reported pain and cognition at a within-person level would allow for the examination of potential contextual effects. More specifically, it could be determined whether fluctuations in pain were related to stress and negative affect and whether these relationships further impact cognitive functioning. It was hypothesized that when negative affect was added to the model, the direct relationship between self-reported pain and cognition would no longer be significant, but the relationship between negative affect and cognition would be significant. More specifically, participants with higher levels of negative affect would have poorer cognitive performance compared to participants with little or no negative affect. Furthermore it was hypothesized that short-term memory (e.g. AVLT) would be most affected by this mediating relationship. With regards to stress, it was hypothesized that when daily stress was added to the model, the pain-cognition relationship would be stronger for individuals with a greater amount of daily stressors compared to those with fewer daily stressors. Short-term memory (e.g. AVLT) and working memory (e.g. N-Back tests) performance were hypothesized to be most affected by this relationship.

Methods

Participants

Participants were recruited from various organizations such as senior centers and community organizations. The current study consisted of 148 independently living, community dwelling older adults. Participants' ages ranged from 60 to 91 years (*M* = 73 years old, *SD* = 6.85). Participants' average yearly income was $32,500 (*SD* = $10,000; range = < $5,000 - >$45,000) and the average years of education was 15.36 years (range = 5-24 years, *SD* = 3.19 years). Approximately 64% of the sample was European American, 35% was African American, and 1% reported being Hispanic. Additionally, 49% of the participants were female.

Measures

Participants were administered a multidimensional battery that assessed socio-demographic characteristics, physical and mental health, and cognitive functioning (see Table 1). The tests were administered in the same order across occasions. Given that many measures were administered repeatedly over a short span of time, eight alternate versions of these measures were administered to reduce the effect of test familiarity. In addition, the order of these alternate versions was counterbalanced across participants. For background on how each of the alternate versions was created, please refer to Allaire and Marsiske (2002). When available, the reliability estimates for the tests are reported.

Table 1
Assessment Battery

Domain	Measures	Baseline	Daily Sessions
Socio-Demographics			
	Demographic Questionnaire	X	
Physical & Mental Health			
	Self-Report Physical Health	X	
	ELSI	X	
	PANAS	X	X
	Daily Pain	X	X
	DISE		X
Cognitive Functioning			
	Verbal Ability	X	
	N-Back	X	X[a]
	AVLT	X	X[a]
	Letter Series	X	X[a]
	Simple Reaction Time	X	X[a]
	Complex Reaction Time	X	X[a]

Note: [a] denotes that 8 parallel versions of the measure were administered across the testing sessions. ELSI = Elders Life Stress Inventory; PANAS = Positive and Negative Affect Schedule; DISE = Daily Inventory of Stressful Events; AVLT = Rey Auditory Verbal Learning Task

Socio-Demographics

Each participant filled out a paper and pencil personal data questionnaire. The questionnaire required the participant to indicate their age, sex, martial status, educational level, race, and average yearly income.

Physical and Mental Health

Daily Pain. A three-item paper and pencil form was used to assess the impact of pain within the past 12 hours. The items assessed the amount of pain, the extent to which the pain has interfered with daily activities, and specific location(s) of the pain. The “amount of pain” question assessed level of daily pain, where low scores indicate little or no pain was experienced within the past 12 hours. The second question referred to the extent to which the pain “interfered” with daily work activities, where low scores indicated that the pain had little or no impact. The third question asked participants to identify the specific location(s) of the pain. The total number of pain locations was used as the score for the third item. These simple questions have been used in a number of other studies (Affleck et al., 1997; Roelofs, Peters, Patijn, Schouten, & Vlaeyen, 2004; Zautra et al., 2001). Refer to the Appendix A for an example of the questionnaire.

Self-Reported Physical Health. Physical health problems were measured using a subjective measure. Participants were asked to indicate whether or not they had ever been told by a doctor or nurse that they had any of the 17 specified health illnesses (see Appendix B for an example of the health conditions). From this subjective health measure, the current study created a composite score, which consisted of a summed score of the present conditions indicated by the participant. The subjective health composite scores ranged from 0 (no indication of health factors) to 17 (identified as having all health conditions). The subjective health composite variable was included in the analyses as a covariate.

Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). This 20-item computerized questionnaire was used to assess an individual's daily experience of positive and negative emotions. At pretest, the participants were asked to rate to what extent they experienced 20 different emotions (e.g. 10 positive and 10 negative) during the past seven days. At the daily sessions, the participants were asked to evaluate their emotions during the past 24 hours. The ten items assessing positive emotion were averaged to create a Positive Affect composite score and the average of the ten items assessing negative emotion was compiled into the Negative Affect composite score. As indicated by Watson et al. (1988), reliability for the positive and negative affect scales was .88 and .87 respectively. To ensure that PANAS-Negative Affect could be used as a proxy for depression in the current study (e.g. as assessed by the CES-D), a correlation in the between the two variables was conducted and found to be significantly related to one another ($r = .66$, $p < .001$) For the purposes of the current study, the negative affect composite score will be used as a proxy variable for depression. An example of this measure is included in the Appendix C.

Elders Life Stress Inventory (ELSI; Aldwin, 1990). The ELSI was used to assess stress at pretest. The original questionnaire contained 31 items which comprise major stressful events that typically occur in adulthood and old age. The questionnaire in the current study included 29 of those items, and excluded the following items: "Institutionalization of a Parent" and "Other". Each item was individually presented on the computer screen and the participant was instructed to indicate whether or not they experienced that stressful life event in the past year. Scores on the ELSI were calculated by summing up the total number of stressful life events experienced by that participant and/or including the individual ratings of how stressful each event was for the individual. Reliability for this measure has not been published, but a thorough background on the development of the measure can be found in Aldwin (1990). See Appendix D for a copy of the questionnaire.

Daily Inventory of Stressful Events (DISE; Almeida, Wethington, & Kessler, 2002). This measure contains seven questions regarding arguments, potential arguments, stressors that occur at work/volunteer settings and home, network stressors (stressors that occur within a network of friends and family), health-related stressors, and other stressors that may have occurred. In addition, a second question asked "How stressful was this event for you", (responses ranged from 1 = not at all stressful to 4 = very stressful). Based on previous research by Mrozcek and Almeida (2004), a composite score was created by multiplying the number of stressors by the reported severity scores for each day. For example, if on a given day an individual reported having three stressors where they gave a total intensity rating of 14 (e.g. 7 for the 1^{st} stressor, 2 for the 2^{nd} stressor, and 5 for the 3^{rd} stressor) their score for that day would be 42. Reliability for the checklist portion has not yet been published. See Appendix E for a copy of the questionnaire.

Cognitive Functioning

The following cognitive ability tests were selected because they have been used in several major investigations of psychometric intellectual aging, including the Seattle Longitudinal Study (e.g., Schaie, 1996), the Adult Development and Enrichment Project (e.g., P. B. Baltes & Willis, 1982), the Berlin Aging Study (e.g., P. B. Baltes & Mayer, 1999), and the Victoria Longitudinal Study (e.g. MacDonald, Hultsch, & Dixson, 2003). Furthermore, they possess adequate psychometric properties, with reliability and validity ratings of at least .65. When applicable, the amount of time taken to complete each test is included in the measure's description.

Verbal Ability Test (Thurstone, 1962). This test was used to assess each participant's verbal knowledge. It required participants to identify the correct definition of a word from a list of possible alternatives. Each item and the answer choices were presented one at a time on the computer screen. The participant chose the correct answer from a list of four possible choices by pressing the corresponding key. The sum of the number of correct responses was used to determine verbal ability. The Verbal Ability test was self-paced; therefore an estimate of how long it took participants to complete the task is not available.

N-Back. The N-Back task was a computer administered test used to assess working memory capacity. A list of 52 letters was presented at the rate of one per second with a 500 millisecond interval between stimuli. The participant's task was to determine whether the letter presented was the same or different than the letter 1-back or 2-back. Participants were told to press the number '1' key when the letter matches the letter of the instructed amount of letters back (e.g. 1-back or 2-back), which is also known as the critical response. Furthermore they were told to press '2' when the letter did not match, which is known as the non-critical response. For example, if the letters presented are K, L, S, L, the responses for the 2-back task to the letter 'L' would be '1' for a match, whereas the response to the letter 'S' would be '2' for a non-match. Based on the work of Nyberg, Dahlin, Neely, and Bäckman (2009), sum scores were calculated for the total number of correct critical responses for the 1-back and 2-back trials. The highest possible total score a participant could receive on the 1-back task was 16, and on the 2-back task the highest score was 15.

Auditory Verbal Learning Test (AVLT; Rey, 1941). The AVLT required participants to study a list of 15 semantically unrelated words on a laptop computer for one minute, after which the list disappeared and participants were told to write down as many words as they could remember. The number of correctly recalled words was used as the total score; there was no penalty for intrusion or perservation errors. The total time allotted to complete the test was two minutes, one minute to study the list and one minute for recall.

Letter Series (Thurstone, 1962). This task was used to assess inductive reasoning, which is defined as the ability to extract novel relationships in over-learned material. Participants were given four minutes to complete as many of the 48 items as they could.

Each item was presented on a computer screen and the participant was asked to identify the letter that would come next in a series of letters. For example if the letters presented were “a b a b c d c” the participant would press the correct letter that would come next in the series which would be “d”. Scores on the test were calculated by summing the total number of correct responses.

Simple and Complex Reaction Time (SRT and CRT; Hultsch et al., 2002). The SRT task was a computer administered self-paced measure that assesses the speed at which participants responded to a target stimulus (box) after presentation of a warning stimulus (plus sign). Participants were asked to press the ‘1’ key as quickly as possible when the signal stimulus appeared. A total of 10 practice trials and 50 test trails were administered. Response times averaged across the 50 test trials were used as the SRT score.

The CRT task presented the participant with two plus signs on the screen, and after a delay of 1000 ms, one of the plus signs changed into a box. The location of the box was randomly equalized across trials. Participants were instructed to press the key that corresponded to the location of the box relative to the plus sign as quickly as possible. A total of 10 practice trials followed by 50 test trials were administered. Following the work of Hultsch and colleagues (Hultsch et al., 2002; MacDonald et al., 2003) scores on the CRT were calculated by averaging the response times across the 50 test trials.

Design and Procedure

The current investigation consisted of secondary data which were collected as part of a larger study. The overarching purpose of the larger study was to design a daily measure of everyday cognitive performance. Consequently, there were additional measures used in the larger study that were not included in the current investigation.

A daily diary design was used, which consisted of a pretest and eight daily sessions. Participants were tested at the local community and/or senior centers from which they were recruited. Once an individual indicated interest in participating, they were contacted and given a brief explanation of the study. If the person agreed to participate, the experimenter then scheduled the pretest session. As stated in the Measures section, eight alternate versions of the cognitive tests were created. To counterbalance for the alternate versions, eight different orders of the alternate test versions were created (e.g. black, blue, green, orange, purple, red, white, or yellow). Once the participant was scheduled, the experimenter then randomly assigned the participant to one of the eight testing orders. Table 2 represents each order and the version number given for each session. At the initial testing session, participants were given a two-hour multidimensional psychological battery consisting of the measures described in the section above. Since testing took place mainly on a laptop computer, the trained experimenter made sure each participant understood how to use all of the required buttons, all of which were clearly labeled and easy to read. At the conclusion of the initial session, the experimenter scheduled the participant's eight daily sessions. All eight of the sessions were completed within three weeks from the date of the pretest. For the daily sessions, participants were administered a shortened assessment battery (as illustrated in Table 1), which took approximately 45 minutes to complete. Participants were compensated $100 for the completion of the pretest and all 8 sessions within the three week time period. The participants who did not complete all testing sessions (*n* = 14) were compensated $20 for completing the pretest session and an additional $10 for each daily session completed.

Table 2
Assigned Testing Order

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8
Black	6	4	3	8	5	2	1	7
Blue	2	6	7	1	4	8	3	5
Green	3	8	6	5	7	4	2	1
Orange	1	7	2	6	8	5	4	3
Purple	7	5	4	3	2	1	6	8
Red	8	1	5	4	6	3	7	2
White	5	2	1	7	3	6	8	4
Yellow	4	3	8	2	1	7	5	6

Note: numbers in the table denote the version given on that session

Power Considerations

Previous studies examining the relationship between pain and cognition have reported medium effect sizes (Brown et al., 2002; Karp et al., 2006; Weiner et al., 2006). The current sample size of 148 provided adequate power ($1 - \beta = .85$) to detect medium effects. With respect to the regression models and multilevel models, attempts were made to collapse the dependent variables to reduce the number of models thereby reducing Type I error. As indicated in the Preliminary Analyses section, none of the factor loadings were strong enough to justify a factor solution; therefore, each of the cognitive tests was analyzed separately. It was estimated that models with three predictors (e.g., self-reported pain, stress, negative affect) would have a power of .97 to detect medium effect sizes. Consequently, the analyses examining within-person associations had sufficient power to detect medium effect sizes given that 148 hundred participants were assessed over 8 occasions (Muthén & Curran, 1997; Raudenbush & Byrk, 2002).

Results

Preliminary Analyses

Examination of Alternate Measurement Versions

With the exception of the Verbal Ability test, eight alternate test versions were used for the cognitive measures (AVLT, Letter Series, SRT, CRT, 1-Back, and 2-Back). A repeated measures analysis of variance (ANOVA) was conducted to examine whether there were significant mean differences in performance across the alternate versions. The measurement versions were represented as the within-subjects factor. The means and standard deviations for the alternate versions are provided in Table 3.

Table 3
Mean Cognitive Performance on the Eight Alternate Versions

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Version 1	7.90 (2.35)[a]	8.64 (3.61)[a]	386.58 (119.44)	548.70 (160.42)	12.86 (3.04)	11.62 (4.12)
Version 2	7.96 (2.55)	9.58 (4.52)[a]	371.27 (102.71)	537.45 (151.36)	13.17 (2.75)	11.13 (3.69)
Version 3	7.72 (2.62)[a]	9.61 (4.65)[a]	379.28 (116.86)	537.25 (134.90)	13.12 (2.61)	11.59 (3.33)[a]
Version 4	7.60 (2.26)[a]	9.33 (4.81)[a]	381.25 (100.80)	536.30 (137.81)	13.03 (2.82)	11.39 (3.58)
Version 5	8.47 (2.50)[a]	8.30 (4.30)[a]	382.97 (115.31)	548.96 (164.16)	12.96 (3.08)	10.59 (3.48)[a]
Version 6	7.96 (2.48)	7.92 (4.39)[a]	383.12 (108.35)	533.13 (131.07)	12.88 (2.87)	11.34 (3.61)
Version 7	8.39 (2.54)[a]	8.65 (4.09)[a]	374.61 (105.81)	548.99 (164.64)	13.18 (2.62)	11.77 (3.54)[a]
Version 8	7.45 (2.23)[a]	9.51 (4.25)[a]	375.45 (104.78)	540.91 (155.33)	13.17 (2.80)	11.62 (3.40)[a]

Note: [a] Indicates a significant mean difference; AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

For AVLT, significant differences were observed among the versions (F (7, 840) = 6.35, $p < .05$, $\eta^2 = .05$). Bonferroni adjusted post-hoc tests indicated that the means for version 5 were significantly higher than the means for versions 1, 3, 4, and 8. Additionally, the mean for version 7 was significantly higher than versions 3, 4, and 8.

For Letter Series, a Greenhouse-Geisser correction estimation was reported due to a significant Mauchly's test ($p < .05$), which suggests that the sphericity assumption was violated. Significant differences were observed among the versions (F (6, 699) = 9.82, $p < .05$, $\eta^2 = .08$). Bonferroni adjusted post-hoc tests indicated that the means for versions 2 and

3 were significantly higher than the means for versions 1, 5, 6, and 7. Additionally, the means for versions 4 and 8 were significantly higher than versions 5 and 6.

For Simple Reaction Time, a Greenhouse-Geisser correction estimation is reported due to a significant Mauchly's test ($p < .05$), which suggests that the sphericity assumption was violated. No significant differences were observed among the versions, F (5, 613) = .844, $p = .53$, $\eta^2 = .007$.

For Complex Reaction Time, a Greenhouse-Geisser correction estimation is reported due to a significant Mauchly's test ($p < .05$). No significant differences were observed among the versions, F (6, 596) = .854, $p = .58$, $\eta^2 = .008$.

For the 1-Back test, a Greenhouse-Geisser correction estimation is reported due to a significant Mauchly's test ($p < .05$). No significant differences were observed among the versions, F (6, 714) = .591, $p = .59$, $\eta^2 = .005$.

For the 2-Back test, a Greenhouse-Geisser correction estimation is reported due to a significant Mauchly's test ($p < .05$). Significant differences were observed among the versions, F (6, 674) = 2.97, $p < .05$, $\eta^2 = .03$. Bonferroni adjusted post-hoc tests indicated that the means for version 3, 7, and 8 was significantly higher than the means for version 5.

Given the differences in alternate versions for some of the cognitive measures, each test's version was standardized to reduce the fluctuation from occasion to occasion due to differences in versions. First, the mean and standard deviation was calculated for each version across occasions and participants. Next, using the mean and standard deviation, each version was standardized to a mean of 50 and standard deviation of 10. Subsequently, the new standardized cognitive variables were used in all within-person analyses[1].

Characteristics of the Data

Each of the cognitive tests was examined for missing data and potential outliers, which were defined as scores ± 3 standard deviations from the mean, participants who did not understand how to complete the task during that given session, or participants who did not perform the computerized task correctly (e.g. pressing the wrong key or not pressing a key at all). Consequently, approximately 3% of the pretest data and 2% of the daily session data had to be excluded or dropped prior to any analyses.

Attrition Analysis

Fourteen of the 148 participants dropped out after completing the pretest; therefore, it was important to determine whether there were significant differences between those who completely dropped out and those who remained in the study. Consequently, three multivariate analyses of variance (e.g. MANOVAs) were conducted using three groups of dependent variables: demographics, physical and psychological functioning, and cognitive performance. If a significant multivariate effect was found, the univariate effects were examined to determine what variables were significantly different between the two groups.

A significant MANOVA was found for the demographic variables (age, education, gender, ethnicity, and income), $F(5, 142) = 2.86$, $p < .05$, $\eta^2 = .09$. When the univariate effects were examined, the two groups only significantly differed by age ($F(1, 147) = 9.13$, p

[1] The standardization of the test versions did not remove any of the variance within and across the occassions of measurement

$< .05$, $\eta^2 = .06$), where those who dropped out were older (*mean* = 78.21, *SD* = 7.34) than those participants who completed all testing sessions (*mean* = 72.56, *SD* = 6.59). A significant MANOVA was also found for the physical and psychological functioning variables (experience of bodily pain, interference of pain, number of pain locations, negative affect, ELSI, and total health conditions), $F(6, 122) = 3.45$, $p < .05$, $\eta^2 = .15$. Results from the univariate effects indicated that both the experience of bodily pain ($F(1, 128) = 7.69$, $p < .05$, $\eta^2 = .05$) and total number of health conditions ($F(1, 128) = 6.23$, $p < .05$, $\eta^2 = .05$) were significantly different by group. More specifically, participants who dropped out had higher ratings of bodily pain (*mean* = 3.50, *SD* = 1.27) and a greater number of total health conditions (*mean* = 2.56, *SD* = 2.88) compared to those that remained in the study (bodily pain: *mean* = 2.38, *SD* = 1.09; total health conditions: *mean* = .92, *SD* = 1.82). When examining the cognitive variables (AVLT, Letter Series, SRT, CRT, 1-Back, 2-Back, and Verbal Ability) the MANOVA was not significant ($F(7, 123) = 1.66$, $p = .13$, $\eta^2 = .09$), indicating that there were no significant differences on cognitive performance when comparing those who dropped out to those that completed all testing sessions.

Data Reduction

Next, a series of preliminary analyses were conducted. First, a Principal Factor Analysis (e.g. PFA) was conducted using the pretest cognitive measures to determine whether the number of cognitive variables could be reduced by creating factors. It was hypothesized that the following three factors would emerge: fluid abilities (AVLT, 2-Back,

& Letter Series), simple abilities (1-Back, Simple Reaction Time, and Complex Reaction Time), and crystallized abilities (Verbal Ability). Interestingly, none of the loadings were strong enough to justify a three-factor or any other factor solution and consequently each of the cognitive tests were analyzed separately.

The items on the pain questionnaire were examined to determine which items would be best to use as a self-reported assessment of pain[2]. First, the correlations between the three self-reported pain questionnaire items were examined. As can be seen in Table 4, the lower diagonal represents the correlations at pretest and the upper diagonal represents the correlations across the eight daily occasions. All three items were significant and highly correlated with one another both at pretest and across the eight daily sessions. Consequently, a self-reported pain composite score was created by multiplying[3] all three pain items (e.g. "How much bodily pain have you had during the past 12 hours" X "During the past 12 hours, how much did pain interfere with your normal work (including both work outside the home and housework)" X "Indicate the location(s) of your pain by circling the bodily locations that apply". Next, the three items, as well as composite score were correlated with the cognitive functioning tests. As illustrated in Table 5, the self-reported pain composite had the greatest number of significant correlations with cognitive performance at pretest and across the eight daily sessions. Consequently, the self-reported pain composite was used in all subsequent analyses.

[2] The percent of days people reported a score on all three pain items was 97%. [3] A sum score of the three pain items was also created. The sum score and multiplication score yielded the same findings.; consequently, only the multiplication score was used.

Table 4
Correlations among the Self-reported Pain Items and the Composite Score at Pretest and Across the Eight Daily Occasions (Lower Diagonal Represents Pretest Correlations and Upper Diagonal Represents Correlations across the Eight Daily Occasions)

	1	2	3	4
1. Interference of Self-Report Pain	-	.52*	.54*	.65*
2. Occurrence of Self-Report Pain	.59*	-	.33*	.80*
3. Number of Pain Locations	.51*	.63*	-	.69*
4. Self-Report Pain Composite	.83*	.63*	.78*	-

Note: * $p < .01$

Table 5
Examining the Relationships between Self-reported Pain Items and Variables of Interest

	Experience of Bodily Pain	Interference of Pain	Number of Pain Locations	Pain Composite Score
Verbal Ability Pretest	-.10	-.08	-.03	-.12
AVLT Pretest	.02	.11	.08	.00
Letter Series Pretest	-.13	-.07	.03	-.07
SRT Pretest	.06	.02	.08	.11
CRT Pretest	.27*	.11	.14	.32*
1-Back Pretest	-.05	.05	.07	-.08
2-Back Pretest	-.22*	-.04	-.11	-.25*
Age	-.08	.04	-.16	-.06
Negative Affect	.02	.20*	.17	.18*
ELSI Pretest	.01	.09	.04	.10
AVLT Daily	.10*	-.00	.69*	.09*
Letter Series Daily	-.04	-.02	.06	.02
SRT Daily	-.00	.04	-.00	.07*
CRT Daily	-.03	-.04	-.03	.01
1-Back Daily	-.04	-.05	-.05	-.08*
2-Back Daily	-.04	-.02	-.08*	-.06
Age	-.06	-.03	-.10*	.09*
Negative Affect Daily	.16*	.20*	.12*	.18*
DISE Daily	.09*	.10*	.06*	.10*

Note: * $p < .05$; AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

The distribution of scores for pretest life-event stress (e.g. ELSI) and daily stress (e.g. DISE) were examined to determine whether or not to leave each as continuous or to create new dichotomous variables. Guidelines provided by Tabachnick and Fidell (1996) were used to determine whether the measures were significantly skewed. The scores on the ELSI were significant and positively skewed where 50% of the participants reported experiencing 8 or less life-event stressors. As a result a dichotomous variable was created using the median split (*median* = 9), where a participant who had a score of 9 or below on the ELSI received a score of "0", and a score of "1" was given for participants who received a score above 9.

Prior to examining the distribution of the DISE, the item on that measure that assessed whether an individual experienced "personal health as a stressor" was found to be highly correlated with the self-reported pain composite ($r = .14$, $p < .01$). Since the study examined whether stress moderated the self-reported pain-cognition relationship, the item was excluded from the analyses to avoid artificially inflating this relationship. Following previous studies (e.g., Mrozcek & Almeida, 2004), the composite score was calculated (e.g. number of daily stressors X reported daily severity scores) for the remaining six items on the questionnaire. Next, the distribution of the DISE composite was examined across all participants and all eight occasions. Similar to the ELSI, the distribution was significant and positively skewed with approximately 46% of the responses scored as having no stress on a particular day. Therefore, a dichotomous variable was created comparing those with at least one reported stressor (DISE = 1) to those without any reported daily stressors (DISE = 0).

Covariates

The relationships between potential covariates and the dependent variables (e.g. standardized cognitive tests) were examined at pretest and across the eight daily sessions to determine which covariates should be included in subsequent analyses. Age, education, income, ethnicity, and gender were included in the correlation matrix as potential covariates at the pretest (Refer to Table 6). The subsequent between-person, or pretest, analyses included the covariates that were significantly associated with a particular dependent variable at pretest. Table 7 represents the daily session correlation matrix, which included the following covariates: the total number of days it took to complete the pretest and daily sessions, the average amount of time between each session, time of day of testing (e.g. AM or PM), total number of sessions completed, linear time, quadratic time, age, education, race, gender, and income. The subsequent within-person analyses included only the covariates that were significantly associated with a particular dependent variable at the daily testing sessions.

Table 6

Correlations between the Cognitive Tests and Demographic Variables at Pretest

	Age	Education	Income	Gender	Ethnicity	Health Conditions
Verbal Ability	-.16	.36*	.36*	.04	-.45*	-.29*
AVLT	-.27*	.17*	.21*	-.29*	-.13	.04
Letter Series	-.37*	.44*	.44*	.15	-.44*	-.23*
SRT	.08	-.30*	-.34*	-.19*	.20*	.10
CRT	-.13	-.14	-.06	-.07	.16*	.21*
1-Back	-.25*	.09	.07	-.01	-.09	-.19*
2-Back	-.17*	.00	.10	-.04	-.10	-.30*

Note: * p <.05; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1; AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

Table 7

Correlations between the Cognitive Tests and Demographic Variables across the Daily Sessions

	Age	Education	Income	Gender	Ethnicity	Health Conditions	Linear Time	Quadratic Time	Time of Day	Average Number of Days	Total Number of Days	Total Number of Sessions
AVLT	-.27*	.14*	.22*	-.24*	-.13*	.08*	.04	.04	.02	-.09*	-.08*	.12*
Letter Series	-.30*	.30*	.29*	.03	.30*	-.14*	.13*	.12*	.06	-.22*	-.14*	.14*
SRT	.02	-.12*	-.21*	-.10*	-.12*	.14*	-.04	-.04	.02	.05	-.01	-.07*
CRT	.06	-.28*	-.38*	-.15*	-.28*	.16*	-.11*	-.09*	-.06	.13*	.09*	-.12*
1-Back	-.11*	.10*	.23*	-.01	.10*	-.26*	.18*	.15*	.03	-.18*	-.13*	.13*
2-Back	-.12*	.17*	.28*	.01	.17*	-.23*	.16*	.14*	.03	-.20*	-.11	.14*

Note:* $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1;

AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

Between-Person Analyses

Aim 1: Examine the extent to which the self-report of pain and age are related to cognitive performance

Hierarchical regressions were estimated for each of the seven pretest cognitive measures. Prior to running the regressions, any independent variable or potential covariate that did not have a meaningful score of zero (e.g. age) was centered by subtracting each participant's score on that variable from the sample mean (individual score – sample mean). The self-reported pain composite, age, and the significant covariates were added in the first step of the model. In the second step, the interaction between the self-reported pain composite and centered age was entered in the model.

Aim 1a: Examine the extent to which the self-report of pain is uniquely related to cognitive performance

Recall from the preliminary analyses that Complex Reaction Time and the 2-Back test were significantly correlated with the self-reported pain composite (refer to Table 6). The goal of this sub-aim was to determine whether a significant relationship between self-reported pain and cognitive performance remained after controlling for the covariates. As seen in Table 8, at step 1, self-reported pain remained a significant and unique predictor for the Complex Reaction Time test. More specifically, higher self-reported pain was related to poorer performance (e.g. slower reaction time) on the test.

Table 8

Aim 1b: Hierarchical Regression Examining Age as a Moderator of the Self-Report Pain-Cognition Relationship

	Verbal Ability	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
Variables	β (*SE*)	β (*SE*)	B (*SE*)	β (*SE*)	β (*SE*)	β (*SE*)	B (*SE*)
Step 1							
Pain Composite	004 (.043)	-.046 (.037)	.007 (.040)	.086 (.026)	.220 (.039)*	.166 (.051)	-.146 (.055)
Education	143 (.242)	.194 (.272)*	.228 (.228)*	-.172 (.194)	-	-	-
Income	.115 (.315)	.188 (.340)*	.101 (.297)	-.265 (.259)*	-	-	-
Gender	-	-.416 (1.68)*	-	-.094 (1.18)	-	-	-
Ethnicity	-.389 (1.537)*	-	-.411 (1.45)*	.048 (1.17)	.142 (1.32)	-	-
Health	-.151 (.456)	-	-.094 (.430)	-	.188 (.427)	-.308 (.511)*	-.214 (.571)*
Age	-.082 (.111)	-.153 (.125)	-.393 (.105)*	.097 (.089)	.074 (.102)	-.225 (.131)*	-.181 (.143)*
Step 2							
Pain Composite	-.016 (.043)	-.044 (.038)	.004 (.041)	.088 (.026)	.227 (.040)*	.170 (.053)	-.153 (.057)
Education	.138 (.242)	.194 (.273)*	.227 (.229)*	-.171 (.195)	-	-	-
Income	.116 (.314)	.188 (.342)*	.101 (.298)	-.265 (.260)*	-	-	-
Gender	-	-.416 (1.68)*	-	-.094 (1.19)	-	-	-
Ethnicity	-.394 (1.54)*	-	-.412 (1.46)*	.049 (1.18)	.144 (1.32)	-	-
Health	-.164 (.458)	-	-.097 (.434)	-	.197 (.431)	-.306 (.521)*	-.219 (.583)*
Age	-.024 (.133)	-.161 (.151)	-.376 (.126)*	.088 (.106)	.036 (.122)	-.231 (.158)*	-.168 (.170)
Pain X Age	-.107 (.005)	.015 (.005)	-.032 (.004)	.015 (.004)	.071 (.004)	.012 (.007)	-.027 (.007)
	R^2	R^2	R^2	R^2	R^2	R^2	R^2
Step 1	.32	.24	.46	.19	.16	.12	.12
Step 2	.32	.25	.47	.19	.17	.12	.12

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1; AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

For the Verbal Ability test, ethnicity was significantly and negatively related to performance such that European Americans performed better on the test compared to African Americans. For 1-Back and 2-Back, total number of health conditions and age were significantly and negatively related to performance. More specifically, individuals who had a higher number of conditions performed worse compared to individuals with fewer health conditions. For Simple Reaction Time, annual income was significantly related to performance where individuals who had a higher annual income performed better than those with a lower annual income. For the AVLT, education and income were significant and positively related to performance. Gender was also significantly related to AVLT performance where men performed better on the test compared to women. For Letter Series, education was positively and age was negatively related to performance. Ethnicity was also significantly related to Letter Series performance where European Americans performed better on the test compared to African Americans

Aim 1b: Examine whether age moderates the relationship between pain and cognitive performance

Step 2 of the hierarchical regression model was used to explore whether age moderated the self-reported pain-cognition relationship. Surprisingly, no significant interactions between self-reported pain and age were found, which suggests that age did not moderate this relationship.

Aim2: Examine whether stress moderates and/or negative affect mediates the relationship between pain and cognitive performance

Two separate sets of seven hierarchical regressions were run, where each of the pretest cognitive tests were included as the dependent variable to determine whether negative affect mediated and/or stress moderated the self-reported pain-cognition relationship. The first set of analyses examined whether life-event stress (e.g. ELSI) moderated the self-reported pain-cognition relationship. In the first step, the ELSI dichotomized variable was added to the model. As can be seen in Table 9, the ELSI was significantly related to performance on the Complex Reaction Time test. More specifically, participants who had a score of nine or higher performed worse on Complex Reaction Time test compared to those with a score less than nine. In the second step, the interaction between self-report pain and the ELSI was added to the model. Surprisingly, no interactions were found between self-report pain and the ELSI, which suggests that life-event stress did not moderate the self-reported-pain cognition relationship.

Table 9
Aim 2: Hierarchical Regression Examining Life-Event Stress as a Moderator for the Self-Report Pain-Cognition Relationship

	Verbal Ability	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
Variables	β (*SE*)	β (*SE*)	β (*SE*)	β (*SE*)	β (*SE*)	β (*SE*)	β (*SE*)
Step 1							
Pain Composite	.-.002 (.043)	-.027 (.037)	.019 (.041)	.073 (.026)	.185 (.039)	.179 (.051)	-.135 (.055)
Education	.141 (.243)	.190 (.271)*	.224 (.228)*	-.170 (.194)	-	-	-
Income	.134 (.311)	.181 (.339)*	.094 (.297)	-.284 (.255)*	-	-	-
Gender	-	-.445 (1.71)*	-	-.060 (1.90)	-	-	-
Ethnicity	-.372 (1.51)*	-	-.408 (1.45)*	.029 (1.15)	.109 (1.28)	-	-
Age	-	-.151 (.125)	-.395 (.105)*	-	-	-.231 (.130)*	-.187 (.142)*
Health	-.158 (.457)	-	-.091 (.429)	-	.193 (.420)	-.300 (.510)*	-.202 (.571)
ELSI	.038 (1.42)	-.124 (1.63)	-.080 (1.33)	.068 (1.16)	.170 (1.29)*	-.112 (1.66)	-.116 (1.78)
Step 2							
Pain Composite	-.126 (.078)	.014 (.086)	.166 (.074)	-.039 (.060)	-.092 (.070)	. 320 (.091)	-.026 (.097)
Education	.136 (.243)	.192 (.273)*	.230 (.228)*	-.175 (.196)	-	-	-
Income	.126 (.313)	.182 (.341)*	.100 (.298)	-.289 (.257)*	-	-	-
Gender	-	-.446 (1.72)*	-	-.056 (1.20)	-	-	-
Ethnicity	-.375 (1.51)*	-	-.408 (1.45)*	.026 (1.16)	.115 (1.27)	-	-
Age	-	-.154 (.127)	-.410 (.106)*	-	-	-.249 (.134)*	-.201 (.146)*
Health	-.165 (.459)	-	-.082 (.431)	-	.177 (.418)	-.293 (.512)*	-.196 (.574)
ELSI	-.007 (1.71)	-.111 (1.94)	-.027 (1.61)	. 033 (1.37)	.072 (1.53)	-.059 (1.99)	-.076 (2.13)
Pain X ELSI	.157 (.086)	-.049 (.096)	-.187 (.082)	.134 (.067)	.150 (.076)	-.183 (.103)	-.141 (.109)
	R^2	R^2	R^2	R^2	R^2	R^2	R^2
Step 1	.31	.26	.47	.19	.18	.13	.13
Step 2	.32	.26	.48	.19	.21	.14	.14

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1; AVLT = Auditory Verbal Learning Test; SRT = Simple Reaction Time; CRT = Complex Reaction Time

The second set of analyses examined whether negative affect mediated the relationship between the self-reported pain composite and cognitive performance at pretest. As discussed by Barron and Kenny (1986), the independent variable, mediator, and dependent variable must be significantly related to one another in order to test for mediation. Recall from Aim 1a, self-reported pain was related only to Complex Reaction Time after controlling for the covariates therefore, a correlation matrix was run only for Complex Reaction Time, self-reported pain, and negative affect. Although negative affect was significantly related to self-reported pain ($r = .18$, $p < .05$), negative affect was not related to Complex Reaction Time ($r = .12$, $p = .14$). Consequently, the criteria necessary to continue with the mediation models, as outlined by Baron and Kenny, was not met.

Within-Person Results

Multilevel modeling (MLM) was used to evaluate the within-person aims. Unlike general linear models (GLM), multilevel modeling (MLM) permits the simultaneous examination of the Level 1, time-varying, and the Level 2, time-invariant predictors. MLM also allows for the assessment of the "coupling parameter", which is defined as the within-person relationship between two variables (e.g. daily pain and daily negative affect).

Prior to running the MLM models, each of the independent variables that did not have a meaningful zero was centered (Singer, 1998). The between-person (Level 2) variables (e.g. age, education, and income) were grand mean centered by subtracting each participant's value on that variable from the sample mean (individual value – sample mean). To compute the coupling parameters, the within-person (Level 1) variables (e.g. self-reported pain and negative affect) were centered by taking each participant's daily score and subtracting it from their own mean calculated over the eight occasions (e.g. occasion pain – mean pain). In addition, the within-person variables were centered at the between-person level by subtracting each participant's mean on that variable from the sample mean (e.g. mean pain – sample mean pain). As indicated in the Preliminary Results section, the DISE was converted into a dichotomous variable; therefore the centering for the variable was different than the other Level 1 variables. Rather than centering at the individual, or within-person level, the dichotomous variable score on a given day (0 = no stress on that day; 1 = at least one stressor occurred on that day) represented the within-person, or daily stress score for that day. The between-person centered variable was created by first computing each individual's percentage of "daily stressors occurred" across the eight occasions. Next, the sample's mean percentage of "daily stressors occurred" was computed. Finally the between-person centered variable was created by subtracting each individual's percentage score from the sample's percentage score (e.g. individual's percentage of "daily stressors occurred" – sample percentage of "daily stressors occurred").

As discussed by Raudenbush and Bryk (2002), prior to running any of the MLM models, it was important to determine whether there was sufficient within- (e.g. Level 1) and between-person (e.g. Level 2) variability in all independent and dependent variables of interest. Consequently, nine fully unconditional models were run where only the intercept was included. Significant variability was found for all six cognitive tests with the within-person variability ranging from 21 – 41% and the between-person variability ranging from 59 – 82%. Significant within- and between-person variability was also found for negative affect (within = 37% between = 63%) and the DISE (within: 71% between: 29%). Refer to Aim 3 for the results for the fully unconditional model pertaining to the self-reported pain composite.

Aim 3: Determine the amount of within- and between-person variability in pain

As previously stated, a fully unconditional model was run to determine whether there was sufficient within- (e.g. Level 1) and between-person (e.g. Level 2) variability in the self-reported pain composite to allow for further analyses (See Equation 1). Results indicated that 31% of the variability in self-reported pain was within-person ($\sigma^2 = 65.26$, $z = 21.71$, $p < .001$) suggesting that there was sufficient fluctuation in the pain measure across the eight occasions. Significant between-person variability was also found ($\tau_{00} = 144.62$, $z = 7.95$, $p < .001$), which suggested 69% of variability in self-reported pain was due to average individual differences.

Equation 1

$$\text{Level 1: Pain}_{ij} = \beta_{0ij} + r_{ij}$$

$$\text{Level 2: } \beta_{0i} = \gamma_{00} + u_{0i}$$

β_{0ij} = Intercept; Pain for person i on day j
γ_{00} = Grand mean/point estimate of pain
u_{0i} = Between-person variability/random error
r_{ij} = Within-person variability/random error

Aim 4a: Evaluate the coupling relationship between daily pain and cognitive performance

To examine the within-person relationship between self-reported pain and cognition, six MLM models (one for each cognitive test) were estimated. In the first step, age, the covariates, and coupling parameter between within-person self-reported pain and cognitive performance were entered into the model. The second step of the model included the cross-level interaction between within-person and between-person self-reported pain. As can be seen in Equation 2, this model allowed for the examination as to whether within-person and between-person self-reported pain was associated with cognitive performance. Although not included in Equation 2, the linear and quadratic effects for time were included in all models. In addition, the slopes were constrained (e.g. random effects were fixed) if the any of the following occurred: the model did not converge, the unconstrained slope (e.g. τ_{11}) was non-significant, and/or the slope could not be estimated.

Equation 2

Level 1: $\text{Cognition}_{ij} = \beta_{0ij} + \beta_{1}$ (Within Pain_{ii} – Between Pain_{i}) + r_{ij}

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}$ (Betwen Pain_{i}– Sample Mean Pain) + u_{0i}

$\beta_{1i} = \gamma_{10} + \gamma_{11}$ (Betwen Pain_{i}– Sample Mean Pain * Within Pain_{ii} – Between Pain_{i}) + u_{1i}

β_{0ij} = Intercept; Pain for person i on day j
γ_{00} = Grand mean/point estimate of pain
γ_{01} = Between-person relationship between mean pain and cognition
γ_{10} = Within-person relationship between mean pain and cognition
γ_{11} = Cross-level interaction between occasion pain and mean pain
r_{ij} = Within-person variability/random error
u_{0j} = Between-person variability/random error
u_{1i} = Variability around the slope between pain and cognition

Table 10
Aim 4a: Multilevel Model Examining the Coupling Relationship between Self-Report Pain and Cognition

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 1						
Within-Person						
Within-Person Pain	.038 (.03)	-.005 (.04)	.013 (.04)	.009 (.02)	-.082 (.04)*	.030 (.03)
Between-Person						
Between-Person Pain	.034 (.03)	.044 (.05)	-.009 (.05)	-.005 (.06)	-.023 (.02)	-.003 (.06)
Age	-.166 (.10)	-.413 (.08)*	-.021 (.09)	-.025 (.10)	-.035 (.09)	-.079 (.10)
Education	.539 (.21)*	.489 (.18)*	-.009 (.99)	-.355 (.23)	-.090 (.19)	-.068 (.21)
Income	.602 (.27)*	.160 (.23)	-.649 (.24)*	-.973 (.29)*	.559 (.25)*	.677 (.27)*
Gender	-7.14 (1.30)*	-	-.662 (1.15)	-.352 (1.43)	-	-
Ethnicity	-1.80 (1.32)	-4.14 (1.15)*	.633 (1.17)	2.84 (1.43)*	-1.28 (1.25)	-3.97 (1.36)*
Health Conditions	.323 (.38)	-.439 (.34)	.520 (.35)	.513 (.42)	-.668 (.37)	-.817 (.39)*
Average Number of Days	.552 (1.32)	-.880 (1.16)	-	-.538 (1.43)	-.712 (1.24)	-1.00 (1.03)
Total Number of Days	-.274 (.20)	-.074 (.17)	-	.107 (.22)	-.146 (.18)	-
Total Number of Sessions	2.12 (.88)*	.526 (.78)	-.925 (.51)	-1.66 (.94)	.652 (.82)	.614 (.81)
Pseudo R^2 between	36%	62%	52%	27%	27%	35%
Pseudo R^2 within	6%	28%	20%	20%	13%	18%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

Table 10 Continued
Aim 4a: Multilevel Model Examining the Coupling Relationship between Self-Report Pain and Cognition

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 2						
Within-Person						
Within-Person Pain	.020 (.04)	-.012 (.04)	.001 (.05)	.008 (.03)	-.106 (.05)*	.054 (.04)
Between-Person						
Between-Person Pain	.034 (.06)	.046 (.05)	-.009 (.05)	-.005 (.06)	-.021 (.05)	-.002 (.06)
Age	-.166 (.10)	-.414 (.08)*	-.008 (.09)	-.025 (.10)	-.034 (.09)	-.079 (.10)
Education	.538 (.21)*	.488 (.18)*	-.023 (.19)	-.354 (.23)	-.093 (.19)	-.068 (.21)
Income	.602 (.27)*	.160 (.23)	-.648 (.24)*	-.974 (.29)*	.556 (.25)*	.677 (.27)*
Gender	-7.14 (1.30)*	-	-.664 (1.15)	-.347 (1.42)	-	-
Ethnicity	-1.80 (1.32)	-4.16 (1.16)*	.628 (1.17)	2.84 (1.43)*	-1.27 (1.25)	-3.97 (1.35)*
Health Conditions	.323 (.38)	-.444 (.34)	.522 (.35)	.509 (.42)	-.682 (.37)	-.823 (.39)*
Average Number of Days	.550 (1.32)	-.871 (1.17)	-	-.530 (1.43)	-.706 (1.24)	-1.00 (1.03)
Total Number of Days	-.277 (.20)	-.080 (.17)	-	.107 (.22)	-.146 (.18)	-
Total Number of Sessions	2.13 (.88)*	.528 (.79)	-.921 (.51)	-1.66 (.94)	.633 (.82)	.608 (.81)
Cross-Level Interaction						
Within Pain X Between Pain	.0004 (.001)	.001 (.001)	.001 (.001)	-.001 (.001)	.002 (.002)	-.001 (.001)
Pseudo R^2 between	36%	61%	52%	28%	28%	35%
Pseudo R^2 within	7%	26%	20%	20%	13%	19%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

As can be seen in step 1 of Table 10, no significant between-person effects for self-reported pain were found. The only significant coupling relationship was a negative relationship between within-person self-reported pain and the 1-Back test. More specifically, on days when self-reported pain was higher than a participants' average, performance on the 1-Back test suffered. A significant and positive between-person effect was found for income.

All slopes were constrained for Simple Reaction Time and only a significant and positive between-person effect was found for income. For Complex Reaction Time, the linear slope for occasion was left unconstrained while the slopes for quadric occasion and within-person self-reported pain were constrained. The between-person effects of income and ethnicity were significant and negatively related to performance For Letter Series the slope for within-person self-reported pain was left unconstrained and the between-person effects of education was positively related, where age and ethnicity were negatively related to performance. For the 2-Back test, the slopes for linear occasion and within-person self-reported pain were left unconstrained. Significant between-person effects were found, were income was positively and ethnicity and total number of health conditions were negatively related to performance. For AVLT, the linear slope was unconstrained and significant effects were found, where education, income, gender, and the number of completed sessions were positively related to performance. For the 1-Back test, the slopes for within-person, self-reported pain and the linear effect of occasion were left unconstrained. As already mentioned, a significant and negative within-person effect for self-reported pain was found for the 1-Back test.

Aim 4b: Examine whether age moderates the coupling relationship between pain and cognitive performance

The following analyses built upon Aim 4a by including a cross-level interaction between within-person self-reported pain and age at Step 1. As illustrated in Equation 3, this model allowed for the examination as to whether the within-person self-reported pain-cognition relationship was different as a function of age. Although not included in Equation 3, the linear and quadratic effects for time were included in all models. Furthermore, the same slopes that were constrained in Aim 4a were constrained in the current aim; therefore the constrained slopes are not reported.

Equation 3

$$\text{Level 1: Cognition}_{ij} = \beta_0 + \beta_1(\text{Occasion Pain}_{ij} - \text{Mean Pain}_i) + r_{ij}$$

$$\text{Level 2: } \beta_0 = \gamma_{00} + \gamma_{01}\,(\text{Mean Pain}_i - \text{Sample Mean Pain}) + \gamma_{02}\,(\text{Age}) + u_{0i}$$

$$\beta_1 = \gamma_{10} + \gamma_{11}\,(\text{Occasion Pain}_{ij} - \text{Mean Pain}_i * \text{Age}) + u_{1i}$$

β_{0ij} = Intercept; Pain for person i on day j
γ_{00} = Grand mean/point estimate of pain
γ_{01} = Between-person relationship between mean pain and cognition
γ_{02} = Between-person relationship between age and cognition
γ_{10} = Within-person relationship between mean pain and cognition
γ_{11} = Cross-level interaction between occasion pain and age
r_{ij} = Within-person variability/random error
u_{0j} = Between-person variability/random error
u_{1i} = Variability around the slope after accounting for age

Table 11
Aim 4b: Multilevel Model Examining the Cross-Level Interaction between Self-Report Pain and Age on Cognitive Performance

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 1						
Within-Person						
Within-Person Pain	.048 (.03)	.003 (.04)	.019 (.04)	.009 (.02)	.063 (.04)	.030 (.03)
Between-Person						
Between-Person Pain	.033 (.06)	.044 (.05)	-.009 (.05)	-.005 (.06)	-.019 (.05)	-.002 (.06)
Age	-.168 (.10)	-.413 (.08)*	-.009 (.09)	-.025 (.10)	-.035 (.09)	-.079 (.10)
Education	.535 (.21)*	.489 (.18)*	-.023 (.19)	-.355 (.23)	-.094 (.19)	-.068 (.21)
Income	.604 (.27)*	.160 (.23)	-.659 (.24)*	-.973 (.29)*	.556 (.25)*	.677 (.27)*
Gender	-7.12 (1.31)*	-	-.654 (1.15)	-.351 (1.43)	-	-
Ethnicity	-1.79 (1.32)	-4.14 (1.15)*	.631 (1.17)	2.84 (1.43)*	-1.26 (1.25)*	-3.97 (1.36)*
Health Conditions	.316 (.38)	-.438 (.34)	.521 (.35)	.513 (.42)	-.682 (.37)	-.819 (.39)*
Average Number of Days	.546 (1.32)	-.881 (1.16)	-	-.537 (1.43)	-.704 (1.24)	-.999 (1.03)
Total Number of Days	-.279 (.20)	-.073 (.17)	-	.106 (.22)	-.148 (.18)	-
Total Number of Sessions	2.12 (.88)*	.526 (.78)	-.926 (.51)	-1.66 (.94)	.627 (.82)	.614 (.81)
Cross-Level Interaction						
Within Pain X Age	.008 (.004)*	-.003 (.006)	.004 (.005)*	.0004 (.003)	.014 (.006)*	-.001 (.004)
Pseudo R^2 between	35%	62%	52%	27%	29%	35%
Pseudo R^2 within	6%	28%	20%	19%	13%	19%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

As can be seen in Table 11, cross-level interactions between within-person, self-reported pain and age was significant for AVLT, Simple Reaction Time, and the 1-Back tests, indicating that age moderated the within-person, self-reported pain-cognition relationship. To examine the interaction for the AVLT test, the interaction was decomposed at three levels of age (-1 *SD* = 66 years, young-old; mean = 73 years, old-old; and +1 SD = 80 years, older-old). As can be seen in Figure 1, the simple slope for the older-old participants (e.g. 80 years old) was significant suggesting that on days when more pain than average was reported, AVLT performance was better. Although the simple slope for the old-old adults (e.g. 73 years old) was non-significant, a positive trend was found where better performance was associated on days when an individual's self-reported pain was higher than average. The relationship for the younger-old adults (e.g. 66 years old) was essentially zero, which indicated that the level of within-person self-reported pain was not associated with AVLT performance.

Figure 1. Cross-level Interaction for AVLT Performance between Within-Person Self-Report Pain and Age

As can be seen in Figure 2, a significant cross-level interaction for within-person self-reported pain and age was found for Simple Reaction Time and was decomposed at three levels (-1 *SD* = 66 years, younger-old; mean = 73 years, old-old; and +1 SD = 80 years, older-old). The simple slopes were only significant for the older-old participants (e.g. 80 years old). Unlike the previous significant cross-level interaction, these findings were in an expected direction, where on days when self-reported pain was higher than an individual's average, their performance was worse (e.g. slower reaction time). Although the simple slope for the old-old adults (e.g. 73 years old) was non-significant, a positive trend was found where worse performance on the test was associated with days when self-reported pain was higher than an individual's average. The relationship for the younger-old adults (e.g. 66 years old) was essentially zero, which indicated that the level of within-person self-reported pain was not associated with Simple Reaction Time performance.

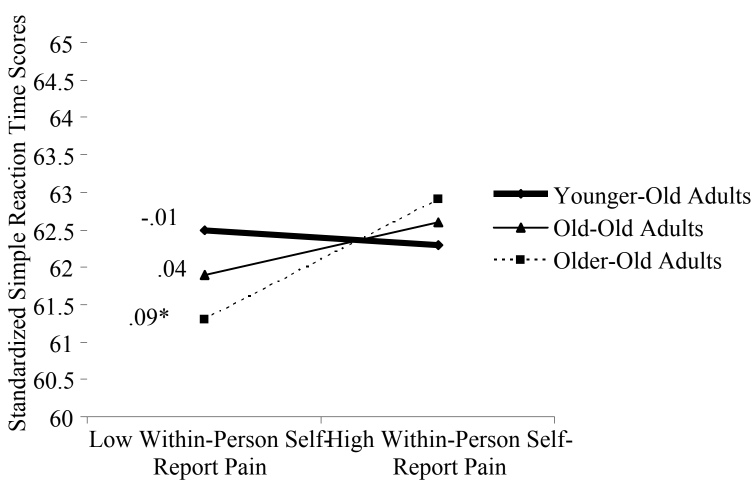

Figure 2. Cross-level Interaction for Simple Reaction Time Performance between Within-Person Self-Report Pain and Age

For the 1-Back test, a significant cross-level interaction for within-person self-reported pain and age was found for the test and was decomposed at three levels (-1 *SD* = 66 years, younger-old; mean = 73 years, old-old; and +1 SD = 80 years, older-old). Unlike the simple slopes for the Simple Reaction Time test, the simple slope was only significant for the younger-old participants (e.g. 66 years old). More specifically, as can be seen in Figure 3, within-person self-reported pain in the younger-old participants was significantly and negatively associated with performance, such that on days when self-reported pain was higher than an individual's average, their performance was lower. Although the simple slope for the old-old adults (e.g. 73 years old) was non-significant, a similar negative trend was found where worse performance on the test was associated on days when self-reported pain was higher than an individual's average. A positive trend was found for the older-old participants (e.g. 80 years old) where on occasions that within-person self-reported pain was higher than their average, their performance was higher.

Figure 3. Cross-level Interaction the 1-Back Test Performance between Within-Person Self-Report Pain and Age

Aim5: Examine whether negative affect mediates and/or stress moderates the coupling relationship between pain and cognitive performance

Two sets of MLM analyses were run to examine whether depression mediated and/or stress moderated the coupling relationship for each cognitive test. The first set of analyses examined whether within-person, or daily stress, moderated the relationship between within-person self-reported pain and cognitive performance. The independent variable (e.g. within-person self-reported pain), the moderator (e.g. daily stress), and the covariates were entered into the first step of the model. The Level 1 interaction between within-person self-reported pain and daily stress was entered into the second step which is illustrated in Equation 4. This model allowed for the examination as to whether the within-person self-reported pain-cognition coupling relationship was different as a function of daily stress. Since age was found to moderate three of the cognitive tests in Aim 4b, a third step was included in the model to test whether there was a three-way interaction between within-person self-reported pain, daily stress, and age. In addition, the slopes were constrained (e.g. random slopes were fixed) if the model did not converge, if the unconstrained slope (e.g. τ_{11}) was non-significant, and/or the slope could not be estimated. At least one slope was unconstrained in each of the models and is described in more detail in the following paragraphs.

Equation 4

Level 1: Cognition$_{ij}$ = β_0 + β_1(Occasion Pain$_{ij}$ – Mean Pain$_i$) + β_2(Occasion Stress$_{ij}$ – Mean Stress$_i$) + β_3(Occasion Pain$_{ij}$*Occasion Stress$_{ij}$) + r_{ij}

Level 2: $\beta_0 = \gamma_{00} + \gamma_{01}$ (Mean Pain$_i$ – Sample Mean Pain) + u_{0i}

$\beta_1 = \gamma_{10} + \gamma_{02}$ (Mean Stress$_i$ – Sample Mean Stress) + u_{1i}

$\beta_2 = \gamma_{20} + u_{2i}$

β_{0ij} = Intercept; Pain for person i on day j
γ_{00} = Grand mean/point estimate of pain
γ_{01} = Between-person relationship between mean pain and cognition
γ_{02} = Between-person relationship between stress and cognition
γ_{10} = Within-person relationship between mean pain and cognition
γ_{20} = Level 1 Interaction between mean pain and stress
r_{ij} = Within-person variability/random error
u_{0j} = Between-person variability/random error
u_{1i} = Variability around the slope after accounting for stress
u_{2i} = Variability around the slope after accounting for stress and pain

As can be seen in Table 12, the covariates that were significant in Aim 4 were also significant in the current aim; therefore they are not described below. The slopes that were left unconstrained in Aim 4 were the same unconstrained slopes in the current aim with the exception of the AVLT, where the linear occasion and within-person, self-reported pain slopes were left unconstrained in the model. In addition, the slope for daily stress was left unconstrained for Letter Series, Complex Reaction Time, and the 1-Back test.

Table 12
Aim 5: Multilevel Model Examining the Level 1 Interaction between Self-Report Pain and Daily Stress on Cognitive Performance

	AVLT *b* (*SE*)	Letter Series *b* (*SE*)	SRT *b* (*SE*)	CRT *b* (*SE*)	1-Back *b* (*SE*)	2-Back *b* (*SE*)
Step 1						
Within-Person						
Within-Person Pain	.032 (.03)	.006 (.04)	.013 (.04)	-.009 (.02)	-.081 (.04)*	.030 (.03)
Daily Stress	.516 (.49)	-.133 (.55)	.023 (.48)	.205 (.36)	-.642 (.43)	.196 (.46)
Between-Person						
Between-Person Pain	.028 (.06)	.030 (.05)	-.009 (.05)	-.006 (.06)	-.022 (.06)	-.004 (.06)
Between-Person Stress	2.25 (2.12)	4.74 (1.86)*	.705 (1.91)	2.39 (2.26)	1.01 (2.01)	.375 (2.16)
Age	-.183 (.10)	-.433 (.08)*	-	-	-.036 (.09)	-.082 (.10)
Education	.466 (.22)*	.378 (.18)*	-.040 (.19)	-.414 (.23)	-.097 (.20)	-.083 (.22)
Income	.579 (.27)*	.133 (.23)	-.621 (.23)*	-.958 (.28)*	.549 (.25)*	.676 (.27)*
Gender	-6.98 (1.31)*	-	-.615 (1.14)	-.349 (1.39)	-	-
Ethnicity	-1.43 (1.34)	-3.54 (1.16)*	.775 (1.18)	3.31 (1.43)*	-1.24 (1.28)	-3.89 (1.39)*
Health Conditions	.301 (.38)	-.470 (.33)	.504 (.35)	.472 (.42)	-.677 (.37)	-.822 (.40)*
Average Number of Days	.627 (1.32)	-.677 (1.14)	-	-.419 (1.43)	-.687 (1.23)	-1.01 (1.04)
Total Number of Days	-.307 (.20)	-.144 (.17)	-	.065 (.22)	-.151 (.19)	-
Total Number of Sessions	2.18 (.88)*	.696 (.78)	-.881 (.51)	-1.49 (.92)	.657 (.83)	.617 (.81)
Pseudo R^2 between	36%	64%	49%	28%	27%	34%
Pseudo R^2 within	7%	30%	19%	21%	13%	18%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

Table 12 Continued
Aim 5: Multilevel Model Examining the Level 1 Interaction between Self-Report Pain and Daily Stress on Cognitive Performance

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 2						
Within-Person						
Within-Person Pain	.014 (.04)	.0002 (.06)	-.001 (.05)	-.019 (.03)	-.123 (.05)*	.006 (.04)
Daily Stress	.519 (.49)	-.131 (.55)	.027 (.48)	.203 (.36)	-.635 (.43)	.198 (.46)
Between-Person						
Between-Person Pain	.029 (.06)	.031 (.05)	-.008 (.05)	-.005 (.06)	-.022 (.06)	-.002 (.06)
Between-Person Stress	2.25 (2.11)	4.73 (1.86)*	.700 (1.91)	2.39 (2.26)	1.00 (2.00)	.363 (2.15)
Age	-.182 (.10)	-.433 (.08)*	-	-	-.036 (.09)	-.081 (.10)
Education	.464 (.22)*	.377 (.18)*	-.042 (.19)	-.416 (.23)	-.102 (.20)	-.087 (.22)
Income	.580 (.27)*	.133 (.23)	-.621 (.23)*	-.959 (.28)*	.549 (.25)*	.676 (.27)*
Gender	-6.98 (1.31)*	-	-.616 (1.14)	-.344 (1.39)	-	-
Ethnicity	-1.42 (1.34)	-3.53 (1.16)*	.777 (1.18)	3.01 (1.43)*	-1.23 (1.28)	-3.88 (1.39)*
Health Conditions	.297 (.38)	-.470 (.33)	.500 (.35)	.466 (.42)	-.691 (.37)	-.832 (.39)*
Average Number of Days	.616 (1.31)	-.681 (1.14)	-	-.427 (1.43)	-.714 (1.25)	-1.01 (1.04)
Total Number of Days	-.304 (.20)	-.143 (.17)	-	.067 (.22)	-.144 (.19)	-
Total Number of Sessions	2.18 (.88)*	.697 (.78)	-.881 (.51)	-1.50 (.92)	.640 (.82)	.611 (.81)
Level 1 Interaction						
Within-Person Pain X	.031 (.06)	.010 (.07)	.023 (.06)	.019 (.04)	.071 (.06)	.043 (.05)
Daily Stress						
Pseudo R^2 between	36%	64%	49%	28%	28%	35%
Pseudo R^2 within	7%	30%	19%	21%	14%	18%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

Table 12 Continued
Aim 5: Multilevel Model Examining the Cross-Level Interaction between Self-Report Pain and Age on Cognitive Performance

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 3						
Within-Person						
Within-Person Pain	.023 (.04)	.019 (.06)	-.016 (.05)	-.018 (.03)	-.126 (.06)*	.007 (.04)
Daily Stress	.558 (.49)	-.216 (.55)	.079 (.48)	.243 (.36)	-.664 (.44)	.156 (.46)
Between-Person						
Between-Person Pain	.029 (.06)	.027 (.05)	-.005 (.05)	-.009 (.06)	-.018 (.06)	-.005 (.06)
Between-Person Stress		4.86 (1.86)*	.637 (1.93)	2.46 (2.29)	1.02 (2.01)	.437 (2.16)
Age	-.190 (.10)	-.401 (.09)*	-.039 (.09)	-.063 (.11)	-.008 (.09)	-.049 (.10)
Education	.458 (.22)*	.386 (.18)*	-.050 (.19)	-.423 (.24)	-.108 (.20)	-.084 (.22)
Income	.582 (.27)*	.134 (.23)	-.635 (.25)*	-.995 (.29)*	.548 (.25)*	.678 (.27)*
Gender	-6.93 (1.31)*	-	-.595 (1.16)	-.213 (1.43)	-	-
Ethnicity	-1.42 (1.34)	-3.53 (1.16)*	.739 (1.20)	3.19 (1.47)*	-1.22 (1.28)	-3.88 (1.39)*
Health Conditions	.287 (.38)	-.428 (.33)	.469 (.35)	.480 (.42)	-.731 (.37)	-.817 (.40)*
Average Number of Days	.597 (1.31)	-.684 (1.14)	-	-.436 (1.44)	-.683 (1.25)	-.992 (1.04)
Total Number of Days	-.304 (.20)	-.147 (.17)	-	.070 (.22)	-.139 (.19)	-
Total Number of Sessions	2.17 (.88)*	.680 (.78)	-.896 (.52)	-1.55 (.95)	.552 (.83)	.590 (.82)

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

Table 12 Continued
Aim 5: Multilevel Model Examining the Cross-Level Interaction between Self-Report Pain and Age on Cognitive Performance

	AVLT	Letter Series	SRT	CRT	1-Back	2-Back
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
Step 3						
Level 1 Interaction						
Within-Person Pain X Daily Stress	.055 (.06)	-.056 (.07)	.074 (.06)	.018 (.04)	.112 (.07)	.032 (.06)
Cross-level Interactions						
Within-Person Pain X Age	.009 (.01)	.011 (.01)	-.005 (.01)	.001 (.004)	.009 (.01)	.003 (.01)
Daily Stress X Age	.014 (.07)	-.079 (.08)	.054 (.07)	.050 (.05)	-.064 (.06)	-.071 (.07)
Three-way Interaction						
Within-Person Pain X Daily Stress X Age	.0004 (.01)	-.027 (.01)*	.017 (.01)	-.002 (.01)	.010 (.01)	-.005 (.01)
Pseudo R^2 between	36%	64%	49%	27%	27%	34%
Pseudo R^2 within	6%	30%	19%	20%	14%	18%

Note: * $p < .05$; Gender: male = 0, female = 1; Ethnicity: European American = 0, African American = 1

A significant and negative within-person main effect of self-reported pain was found for the 1-Back test, where greater pain on a given day was associated with worse performance. Interestingly, a significant and positive main effect of between-person stress was found on the Letter Series test, where better performance was associated with participants who reported high average stress. Furthermore, a three-way interaction between within-person self-reported pain, daily stress, and age was found for the Letter Series test.

The significant three-way interaction for Letter Series performance indicated that the relationship between within-person self-reported pain varied as a function of daily stress and age. As can be seen in Figure 4, on days when the younger-old adults reported no stressors, higher then their average self-reported pain was associated with better performance. In contrast, on days when younger-old adults who reported having at least one stressor, higher than their average self-reported pain was associated with worse performance. The opposite trend was found for the older-old adults. More specifically, on days when an older-old participant reported no stressors, higher than their average self-reported pain was associated with worse performance. On days when an older-old participants reported having at least one stressor, higher than their average self-reported pain was associated with better performance.

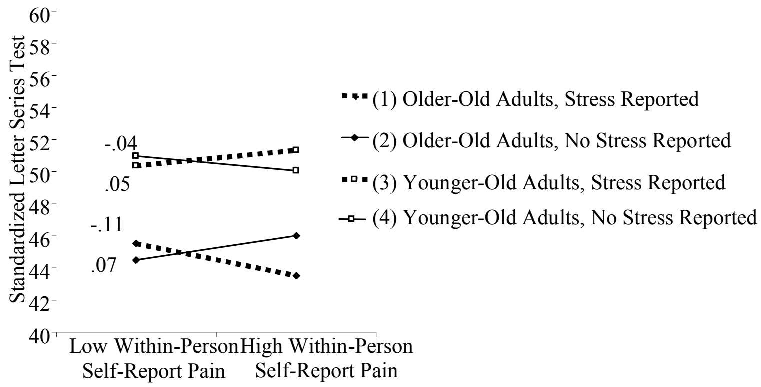

Figure 4. Three-Way Interaction for the Letter Series Test between Within-Person Self-Report Pain, Daily Stress, and Age

For the second set of analyses, lower level mediation was conducted since the independent variable (e.g. the within-person self-reported pain), the mediator (e.g. daily negative affect), and the dependent variables (e.g. cognitive performance) are all Level 1 variables (refer to Kenny, Korchmaros, & Bolger, 2003). As previously stated, the first step of mediation is to demonstrate that there is a relationship between the independent variable and the dependent variable (Baron & Kenny, 1986). Therefore, six separate multilevel models were run for each cognitive test which included within-person self-reported pain and the covariates. This model is the same set of analyses that were conducted in Step 1 of Aim 4b. As can be seen above in Table 11, the only significant relationship between the independent variable and the dependent variable was found for the 1-Back test. Consequently, the second step which requires that a relationship exists between the independent variable and the mediator, can only be conducted on 1-Back test. To test this relationship, negative affect was entered as the dependent variable and within-person self-reported pain was entered as the independent variable. Unfortunately, no significant relationship was found between within-person self-reported pain and negative affect (β = .005, p = .58), therefore the test for mediation can not be continued any further.

Exploratory Analyses

Examining Negative Affect as a Moderator

Given that the hypothesized mediation of negative affect could not be tested at the pretest or across the eight occasions, exploratory analyses were conducted to examine whether negative affect was a moderator. In fact research has suggested that negative affect may play a moderating role in conjunction with pain (Conner, et al., 2006; Kewman, et al. 1991; Mossey, et al., 2000). Bunce and colleagues (2008a; 2008b) have suggested that intrusive thoughts relating to the depressive symptoms can reduce the amount of available resources needed to complete cognitive tasks. Therefore, a possible rationale for the proposed relationship between self-reported pain and negative affect is that the combined interference effects of negative affect and self-reported pain would result in decrements in cognitive performance. Thus it was hypothesized that the pain-cognition relationship would be strongest for individuals who report experiencing both pain and negative and weakest for individuals who do not report experiencing pain or negative affect. Consequently each aim pertaining to negative affect was reanalyzed to include the variable as a moderator.

Between-Person Analysis

First Aim2, was reanalyzed where each of the pretest cognitive measures were included as the dependent variable. The self-reported pain composite, negative affect, and the significant covariates of the dependent variable were added to the first step of the model. In the second step, the interaction between the self-reported pain composite and centered negative affect was entered in the model. In the third step, a three-way interaction between self-reported pain, negative affect, and age was entered in the model. No significant main effects for negative affect were found, but a significant interaction for Complex Reaction Time performance was found where the relationship between self-reported pain and processing speed performance was different as a function of negative affect ($\beta = .023$, $SE = .008$, $p < .01$). To further examine this relationship, the interaction was decomposed at three levels (e.g. -1 *SD* 1.05, mean 4.44, and +1 *SD* 7.83). As can be seen in Figure 5, the simple slopes were significant for participants with high negative affect, where higher self-reported pain was associated with worse performance on the Complex Reaction Time test. A similar trend was found for participants with mean negative affect, where high self-reported pain was associated with worse performance. In contrast the opposite trend was found for participants with low negative affect, where high self-reported pain was associated with better performance.

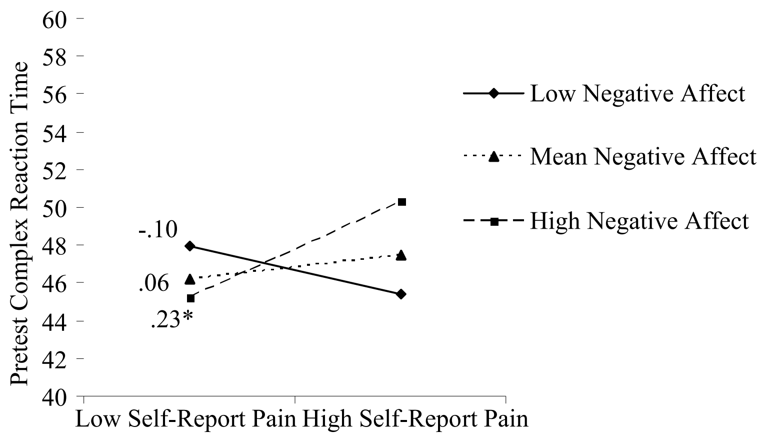

Figure 5. Negative Affect Significantly Moderated the Relationship between Self-Report Pain and Complex Reaction Time Performance at Pretest

Within-Person Analysis

Next the within-person, daily aim (Aim 4b) relating to negative affect was examined. The independent variable (e.g. within-person self-reported pain), the moderator (e.g. daily negative affect), and the covariates were entered into the first step of the model. The Level 1 interaction between within-person self-reported pain and daily negative affect was entered into the second step. A third step was included in the model to test whether there was a three-way interaction between within-person self-reported pain, daily negative affect, and age.

A significant within-person, self-reported pain by daily negative affect interaction was found for the 1-Back ($\beta = .042$, $SE = .020$, $p < .05$) and 2-Back tests ($\beta = .039$, $SE = .020$, $p < .05$). To further examine the interaction for the 1-Back test, the interaction was decomposed at three levels of negative affect (e.g.-1 *SD*, 5.63, mean 0, and +1 *SD* 5.63). As can be seen in Figure 6, the simple slopes were significant and negative for participants with low and mean daily negative affect. More specifically, on days when self-reported pain was higher than an individual's average, their performance was worse. A similar trend was found for participants with high daily negative affect, where on days when self-reported pain was higher than an individual's average, their performance was worse.

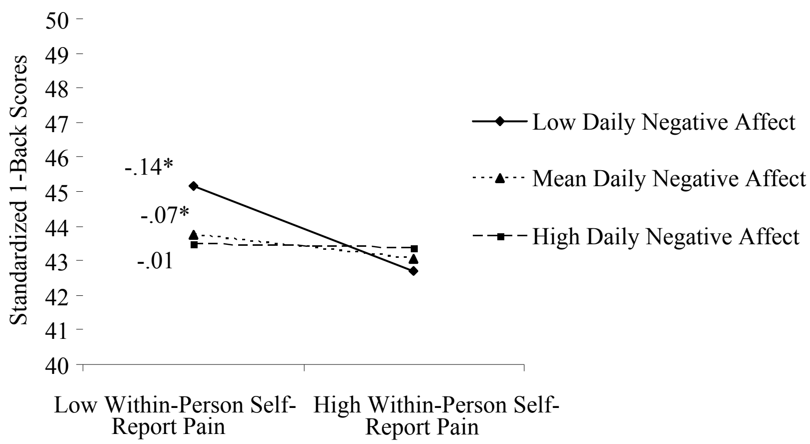

Figure 6. Daily Negative Affect Significantly Moderated the Relationship between Within-Person Self-Report Pain and 1-Back Performance across the Eight Occasions

To further examine the interaction for the 2-Back test, the interaction was decomposed at three levels of negative affect (e.g.-1 *SD* -5.63, mean 0, and +1 *SD* 5.63). As can be seen in Figure 7, a negative trend was found for participants with low daily negative affect. More specifically, on days when self-reported pain was higher than an individual's average, their performance was worse. In contrast, the opposite trend was observed for participants with mean and high daily negative affect, such that on days when an individual's pain was higher than their average performance was better.

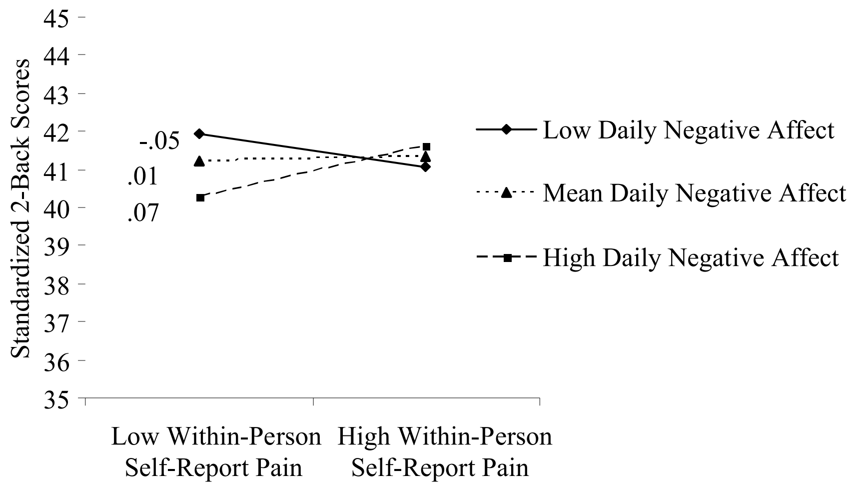

Figure 7. Daily Negative Affect Significantly Moderated the Relationship between Within-Person Self-Report Pain and 1-Back Performance across the Eight Occasions

Two significant three-way interactionsbetween within-person, self-reported pain, negative affect, and age were found for Letter Series ($\beta = -.01$, $SE = .002$, $p < .05$) and Complex Reaction Time performance ($\beta = -.004$, $SE = .002$, $p < .05$), where the relationship between within-person self-reported pain and cognitive performance varied as a function of daily stress and age. For the Letter Series test, the interaction was decomposed and as can be seen in Figure 8 the younger-old adults performed better on the task compared to the older-old adults. Furthermore, on days when an older-old participant reported low negative affect, higher than their average self-reported pain was associated with better performance. Alternately, on days when older-old participants reported having high negative affect, higher than their average self-reported pain was associated with worse performance. The simple slopes for the younger-old adults were relatively flat suggesting that daily average pain was not associated with Letter Series performance.

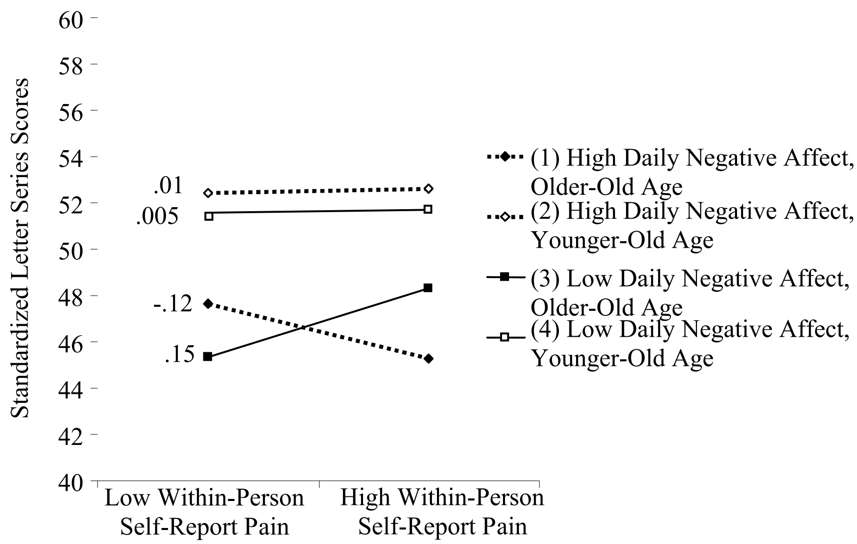

Figure 8. Daily Negative Affect and Age Significantly Moderated the Relationship between Within-Person Self-Report Pain and Letter Series Performance across the Eight Occasions

For the Complex Reaction Time test, the interaction was decomposed and as can be seen in Figure 9, the opposite effect was found for the older-old participants. More specifically, on days when an older-old participant reported low negative affect, higher than their average self-reported pain was associated with worse performance. Alternately, on days when older-old participants reported having high negative affect, higher than their average self-reported pain was associated with better performance. The simple slopes for the younger-old adults were relatively flat suggesting that within-person self-reported pain was not associated with Complex Reaction Time performance.

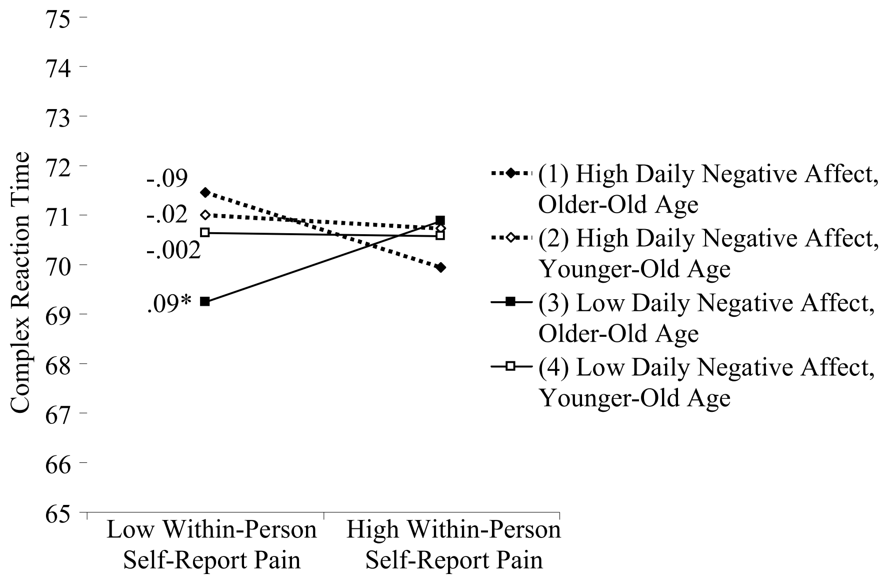

Figure 9. Daily Negative Affect and Age Significantly Moderated the Relationship between Within-Person Self-Report Pain and Complex Reaction Time Performance across the Eight Occasions

Discussion

The following section is divided into four subsections. The first discusses the major findings associated with each specific aim of the study including theoretical rationale for the observed results. The second section describes the limitations of the current investigation. The third section suggests directions for future research with respect to the study of self-reported pain and cognitive performance in older adults. The final section offers a conclusion focusing on the general theoretical rationale and empirical implications for the findings.

Before the findings are discussed, it is important to reiterate the overarching aim of the current investigation and its contribution to cognitive aging research. In general, the current investigation attempted to examine the direct and indirect links between self-reported pain and cognitive functioning in a sample of older adults. This is an area of research that has received little attention in the aging literature, particularly within samples of community-dwelling older adults. In fact, the current study is one of the first to explore the direct pain-cognition relationship and the potential mediating (e.g. negative affect) and moderating factors (e.g. age and stress) of this relationship. In addition, the study took advantage of a rich data set and explored these relationships at the between-person and within-person levels of analysis.

Review of the Findings

Between-Person Findings

The first sub-aim (Aim 1a) of the investigation was to determine whether there was a direct relationship between self-reported pain and cognitive performance at pretest. It was hypothesized that a significant relationship would be found for the complex cognitive tests such as the AVLT, Letter Series, and N-Back tests. Contrary to expectations, only the Complex Reaction Time test was significantly related to self-reported pain. Although these results do not support the original hypothesis, they are in line with the findings of Schmand and colleagues (1998) who reported that performance on a processing speed task was significantly worse in the pain participants relative to the no-pain participants. In addition, they found only marginal differences in verbal ability and fluency test performance, and no executive functioning differences were found. This finding may be explained by the hypothesis that both pain and cognition are competing for finite available resources (Hart et al., 2003; Karp et al., 2006). The competition for resources makes it difficult to simultaneously ignore the pain and focus on the cognitive task at hand. In fact, Gibson (2008) has proposed that the experience of pain may have a greater impact on processing speed and cognitive abilities that require attentional demands such as working memory tests. Furthermore, Gibson states that as pain-related thought intrusions compete for limited attentional resources, capacity for attentional processing is reduced; thereby limiting the capacity that is needed to effectively process information. Consequently, the intrusion of pain would most likely impede on the ability to focus on tasks that require a great amount of attention in a limited amount of time, rather than on short-term memory or reasoning tasks.

One may argue that if the pain-cognition relationship is found in tasks reliant on attentional processes, the current study should have also found significant effects for at least Simple Reaction Time and possibly 1-Back, and 2-Back performance as well. It could be the case that the Simple Reaction Time was too easy and therefore it may not truly tap into individual differences in processing speed performance. The score distribution (e.g. kurtosis) was examined to determine the extent to which the scores were evenly spread about the normal curve. Using the guidelines provided by Tabachnick and Fidell (1996) the kurtosis was found to be leptokurtic, meaning that the distribution of scores was highly concentrated around the mean. This suggests that there was not much variance in performance on the

Simple Reaction Time test. In contrast, the N-Back tests may have been too difficult since the working memory task requires the concurrent use of multiple cognitive domains (e.g. short-term memory, processing speed, and attention; Schmiedek, Li, & Lindenberger, 2009). The considerable amount of attentional demands needed to complete the tasks may have exceeded the amount of demands required for attending to current pain levels, such that the attention demands of the task were overriding the attention to pain; therefore a relationship could not be detected. Alternatively, the cognitive demands (e.g. processing speed and "choice" decision making) required by Complex Reaction Time were difficult enough to detect individual differences in performance, and easy enough to detect the additional attention demands caused by the interference of self-reported pain.

The goal of Aim 1b was to determine whether age moderated the between-person self-reported pain-cognition relationship. Recall that there were two competing hypotheses for this relationship. The first was that the relationship would be weaker in the older-old participants compared to the younger-old participants as a result of age-related increases in the threshold to pain (Pickering, et al., 2002; Quiton et al., 2007). The second hypothesis was that the relationship would be stronger in the older-old participants compared to the younger-old participants as a result of age-related declines in inhibitory processing (Hartman & Hasher, 1991; Hasher, et al., 1999). Surprisingly, no significant interactions were observed between self-reported pain and age, suggesting that age-differences in pain thresholds or inhibition do not contribute to the strength of the pain-cognition relationship.

The goal of Aim 2 was to determine whether stress moderated and/or negative affect mediated the between-person self-reported pain-cognition relationship. For stress, it was hypothesized that the pain-cognition relationship would be strongest for those participants who reported experiencing and being affected by life-event stressors that occurred in the past year compared to those that reported fewer experiences or not being affected by past stressors. The rationale for this relationship is that experiencing life-event stressors would increase the level of stress-related intrusive thoughts and these thoughts would produce cognitive interference (Klein & Barnes, 1994). Since previous research has shown that life-event stress was strongly related to working memory and short-term memory, it was further hypothesized that the moderating relationship would be strongest for AVLT, Letter Series, and the N-Back tests.

Life-event stress was not found to be a significant moderator of the between-person self-reported pain-cognition relationship. Recall, the pretest stress measure assessed life-event stressors that have occurred over the past year. Even though the measure asks participants to indicate how stressful the event was, it does not tap into how much stress the participant is <u>currently</u> experiencing. It could be the case that a participant who reports experiencing a number of stressful life events over the past year but has successfully adapted to, or resolved these issues, will no longer experience stress or stress-related intrusive thoughts that use up available resources. By simply asking someone about past stressors, the individual differences in intrusive thoughts about those stressors are overlooked. A measure that taps into the current intrusive thoughts related to stressful life-events may be better at detecting the moderating role of life-event stress.

For negative affect, it was hypothesized that the experience of pain may lead to greater negative affect perhaps due to pain-related decreases in mobility, sense of loss of internal control, and/or decreased social interactions (Parmelee et al., 1991; Skevington, 1983). In turn, greater negative affect is related to poor cognitive performance (e.g., Baune et al., 2006). Previous research has shown a strong relationship between negative affect and short-term memory (Baune et al., 2006; Lichtenberg et al., 1995), therefore it was hypothesized that negative affect would mediate the pain-cognition relationship and the strongest relationship would be for the AVLT. Unfortunately, the mediation relationship of negative affect could not be tested as a result of the absence of significant relationships between self-reported pain, negative affect, and performance on any of the cognitive tests. More specifically, only the Complex Reaction Time test was found to be significantly related to self-reported pain; therefore this was the only cognitive variable in which the mediated relationship between negative affect and cognition could be tested and unfortunately, a significant relationship was not found. The inability to test for mediation suggests that negative affect does not serve as an underlying mechanism for the pain-cognition relationship.

Within-Person Findings

The first goal of the within-person aims (e.g. Aim 3) was to determine the extent to which self-reported pain varied from occasion to occasion. Based on previous research (Finan, et al., 2008; Kratz, et al., 2007), it was hypothesized that significant individual differences and within-person fluctuation of self-reported pain would be observed. The current study found that 69% of the variability in self-reported pain was due to between-person differences and 31% of the variability was due to within-person fluctuations. Interestingly, these findings are identical to those of Focht and colleagues (2002) who found that 68% of variability in reported pain was due to between-person differences and 32% was due to within-person fluctuations. These results suggest that the self-report of pain does in fact change from day to day, and that a one time assessment of self-reported pain may not be accurately tapping into an individual's experience of pain.

The goal of Aim 4a was to determine whether there was a coupling relationship between within-person (e.g. daily), self-reported pain and cognitive performance. Similar to Aim 1, it was hypothesized that the relationship would be strongest for the complex cognitive tests such as AVLT, Letter Series, and N-Back tests. The hypothesis was partially supported; a significant coupling effect was found among within-person, self-reported pain and 1-Back performance. In particular, on days when self-reported pain was higher than an individual's average, working memory performance suffered. No other significant coupling effects were found for the hypothesized cognitive measures (e.g. AVLT, Letter Series, and 2-Back test).

As previously discussed in the between-person findings, the N-Back tasks may have required a substantial amount of attentional demands compared to simpler tasks such as AVLT and Letter Series. More specifically, it was hypothesized that the interference of pain did not use up the amount of the available resources needed to complete the simpler tasks (e.g. AVLT, and Letter Series). In contrast, the 2-Back task may have been too difficult of a task to detect individual differences on the impact of daily self-reported pain. For the 1-Back test, the interference of self-reported pain used up some of the available resources needed to successfully complete a moderately complex task, causing performance to suffer.

For Aim 4b, the cross-level interaction between self-reported pain and age was examined. The hypotheses were similar to Aim 1b, where the pain-cognition relationship would be weaker for the older-old adults as a function of an age-related increase in threshold for pain (Pickering et al., 2002; Quiton et al., 2007), or would be stronger as a function of the age-related decrease in inhibitory control (Hartman & Hasher, 1991; Hasher et al., 1999). A significant within-person self-reported pain and age interaction was found for 1-Back performance such that on days when a younger-old participant's pain was higher than their average, their performance on the test suffered. It could be hypothesized that the younger-old adults were not able to ignore the pain on days it was higher than their average, consequently their performance on the demanding, working memory task suffered. The relationship was not significant for the old-old and older-old participants. It could be the case that the task was too difficult for the older-old adults and they were performing at floor and thus variability in performance on that measure could be not detected. Therefore, the association between self-reported pain and age could only be detected within the younger-old sample that may have had more available resources to complete the task compared to the older-old participants.

In contrast, findings from the Simple Reaction Time test demonstrated a significant relationship for the older-old adults, where worse performance was associated on days when they reported pain higher than their average. This finding supports the hypothesis that the pain-cognition relationship is stronger in the older-old participants as a function of age-related declines in inhibition. It could be the case that since the task was relatively simple, the older-old adults did not attempt to ignore the irrelevant interference of pain, and thus the pain intruded and their performance on the task suffered.

For the AVLT, a significant relationship was also found for the older-old adults, but interestingly better performance was associated with days when they reported pain higher than their average. Since the AVLT, to some extent, may lend itself to the use of strategies, it may be possible that the older-old participants who were experiencing high pain, on average, were attempting to take their mind off the pain by putting forth more effort towards the task. As a result, the older-old participants were able to focus on the task at hand and possibly use strategies that could be beneficial for completing the task.

Aim 5 examined the extent to which daily stress moderated and negative affect mediated the within-person pain-cognition relationship. Similar to Aim 2, it was hypothesized that the pain-cognition relationship would be strongest for individuals who reported experiencing at least one daily stressor compared to those that reported experiencing no stressors on that day. It is important to note that the daily stressor measure may be a more accurate assessment of current stress, since it asks the participant to indicate if a stressor occurred within the past 24 hours and how much has it affected them during this more recent timeframe. Furthermore, it was proposed that the cognitive tests most affected by the moderating relationship would be the AVLT and N-Back tests. Since age was found to moderate the pain-cognition relationship for three of the tests, it was also included in the analyses to examine whether it added anything to the within-person self-reported pain, daily stress, and cognition relationship.

Unfortunately, a Level 1 interaction between within-person pain and daily stress was not found, but a three-way interaction between within-person self-reported pain, daily stress, and age was found for the Letter Series test. When examining age differences in performance for participants who reported no stressors on that day, better performance was associated with the older-old participants who reported higher than their average pain. This finding is somewhat similar to the findings relating to the pain and age relationship on AVLT performance. Since the Letter Series requires the use of strategies to complete the task, it is possible that the older-old participants who were experiencing higher-than-average pain were attempting to take their mind off the pain by putting forth more effort towards the task. As a result, the older-old participants were able to focus on the task at hand and use effective strategies to successfully complete the task. The opposite effect was found when comparing age differences in performance on days when at least one stressor was reported. On days when older-old participants experienced at least one stressor, higher than their average reported pain was associated with worse performance. It could be the case that the simultaneous interference from the intrusive thoughts relating to both pain and stress may have interfered with an individual's cognitive ability. Again, fewer resources were available to use potential strategies that could be used to complete the task.

Similar to Aim 2, the mediating effect of negative affect could not be tested as a result of the lack of significant relationships among within-person self-reported pain, negative affect, and the cognitive tests. More specifically, only the 1-Back test was found to be significantly related to within-person self-reported pain; therefore this was the only cognitive variable in which the relationship between negative affect and cognition could be tested and unfortunately, a significant relationship was not found.

Exploratory Findings

Since the mediation of negative affect could not be tested at the between- or within-person level, it could be the case that negative affect actually moderated the pain-cognition relationship. In fact research has suggested that negative affect or depressive-symptoms may play more of a moderating role in conjunction with pain (Conner, et al., 2006; Kewman, et al. 1991; Mossey, et al., 2000). Bunce and colleagues (2008a; 2008b) have suggested that intrusive thoughts related to depressive symptoms can reduce the resources available to complete cognitive tasks. Therefore, a possible rationale for the proposed relationship between self-reported pain and negative affect is that the combined interference effects of negative affect and pain would result in decrements in cognitive performance. Thus, it was hypothesized that the pain-cognition relationship would be strongest for individuals who report experiencing high negative affect and weakest for individuals with low negative affect.

To test this hypothesis a set of exploratory analyses were conducted to examine whether negative affect moderated the pain-cognition relationship. The aims (e.g. Aims 2 and 5) that originally hypothesized that negative affect was a mediator, were reanalyzed to include negative affect as a moderating variable. A significant interaction effect was found at the pretest for Complex Reaction Time. When the interaction was decomposed, the simple slope for individuals with high negative affect was significant, where worse performance was associated with high self-reported pain. The simple slopes for participants with low or average negative affect were non-significant. These findings support the hypothesis that the pain-cognition relationship is the strongest for individuals with high self-reported pain and high negative affect. Furthermore, recall that self-reported pain was also significantly associated with Complex Reaction Time performance in Aim 1, therefore by including negative affect as a moderator, the relationship between self-reported pain and "complex" processing speed can be better understood. It could be the case that the relationship between intrusive thoughts relating to self-reported pain and negative affect further reduces the availability of resources needed to effectively complete the processing speed test.

In regards to the within-person relationships, significant within-person self-reported pain by daily negative affect interactions were found for the 1-Back and 2-Back working memory tasks. For the 1-Back task, level of self-reported pain was not associated with cognitive performance on days characterized by high negative affect. In contrast, a significant effect was found for those participants who experienced low or negative affect, such that higher than average pain was associated with worse cognitive performance. Thus, it could be the case that the experience of high negative affect “masks” the coupling relationship between self-reported pain and a complex task such as a working memory task. Furthermore, the effect of self-reported pain on the working memory task can be best seen when negative affect is lower than an individual’s average. These results suggest that an individual’s appraisal of pain may vary depending on their mood at the time. It could be hypothesized that varying appraisals have differential effects on working memory performance.

The decomposition of the 2-Back interaction suggested that those participants who experienced low daily negative affect tended to perform worse on those days when they experienced high pain. This is consistent with the previous finding for the 1-Back test. Interestingly, the findings also suggested that those participants who experienced high daily negative affect tended to perform better on those days when they experienced high pain. It could be the case that when the task became increasingly challenging, those participants who were experiencing negative affect were able to use their current mood state to their advantage. More specifically, research has suggested that individuals who are in a negative mood tend to use more bottom-up processing (Bless & Fielder, 2006; Clore, Casper, &

Garvin, 2001). Thus these individuals' attention to detail as a result of their negative mood state may have been beneficial for completing this complex working memory task.

A 3-way interaction at the within-person level was found for within-person self-reported pain, negative affect, and age for the Letter Series test. A similar relationship was observed for the within-person self-reported pain by age by daily stress interaction for this same task.

These findings provide further support that a cumulative occurs for older-old adults when an additional negative factor (e.g. stress or negative affect) is present in conjunction with pain. Thus, it could be the case that when older-old adults experience pain alone they are still able to effectively perform cognitively challenging tasks. However, cognitive performance begins to suffer when pain and additional negative factors are concurrently present.

For Complex Reaction Time performance, on days when the older-old individuals experienced high negative affect, their performance tended to be better when they also experienced high pain. These findings were surprising given that the previous findings relating to the same task suggested that high negative affect was associated with worse performance particularly on those days when they also experienced pain. One possible rationale for this interesting finding is that these individuals wanted to complete the task as fast as possible, because they may not have wanted to use up available resources needed to complete this somewhat simple or basic task. Recall that performance on this task did not take into account accuracy; so it is unclear whether on these occasions an individual's physical and mental state was beneficial or just a consequence of wanting to simply finish the task.

Limitations of the Current Study

The current study attempted to examine the extent to which the experience of pain was related to cognition in a sample of community-dwelling older adults. This study was unique in that it utilized a rich data set, where for the first time, the within-person pain-cognition relationship and its potential mediators and moderators was explored among healthy older adults. However, there are a number of limitations that should be considered alongside the results. One limitation of the study was that all the cognitive tests took place on a computer. Since the sample consisted of older adult participants, a majority of them may be been unfamiliar with the laptop and how to use the designated keys on the keyboard. This limitation was most pronounced at the pretest, where for some, completing the task was made increasingly difficult as a result of the required demands of using a novel device (e.g. the laptop).

Another limitation of the current investigation was that the pretest, life-event stressor questionnaire (e.g. ELSI) did not tap into the current level of the participant's stress. Although it was important to assess stressors that have occurred in the past year, it was not a useful tool for the measurement of current stress at the pretest, baseline assessment. The daily stressor questionnaire (e.g. DISE), may have been a more useful tool to use at the pretest assessment when examining the extent to which self-reported pain and cognition was moderated by stress.

One other possible limitation relating to the assessment of stress was that recent research has suggested that a composite stress score is not the best when examining its relationship with cognitive performance (Rosnick, Small, McEvoy, Borenstein, & Mortimer, 2007). It might have been more beneficial to examine the consequences of each stressor separately. If each individual stressor was examined, the current study may have found greater associations among self-reported pain, stress, and cognitive performance.

Testing the participants in a setting familiar to them may have been just as detrimental as it was beneficial. More specifically, since the participants were tested at their local church or senior center, the current study was unable to ensure optimal testing conditions. As a result, factors such as outside noise, extreme/uncomfortable temperatures, and/or the level of comfort regarding table and chair in which the participant sat may have been potentially influenced some the findings.

Finally, a major limitation was that the self-reported pain measure used in the current study consisted of only three items. Consequently, the measure was unable to tap into various dimensions related to pain (e.g. interference, controllability, affective distress, social support). Although this is a limitation, a number of studies have used these types of unidemensional questions (Affleck et al., 1997; Conner, et al. 2006; Roelofs et al., 2004; Zautra et al., 2001).

Future Directions

The current investigation has made an attempt to begin to understand the extent to which self-reported pain is related to cognitive performance and the role of potential mediators and moderators of that relationship. This study uncovered some interesting links between the self-reported pain and cognition relationship. However it does not offer a full explanation of this association among older adults and there are a number of suggestions for future research so that the study of the pain-cognition relationship in older adults can progress.

Recall that one of the proposed rationales for the pain-cognition relationship was that pain and cognition are competing for limited available resources (Hart et al., 2003; Karp et al., 2006). Furthermore, it was hypothesized that the experience of pain, stress, and negative affect may have a greater impact on cognitive abilities that require the most attentional demands (Gibson, 2008). Thus, it would be important to include a measure that assesses whether the experience of pain leads to intrusive thoughts in order to assess whether those pain-related intrusive thoughts lead to poor cognitive performance. In addition, a cognitive measure that has been shown to be associated with inhibitory control should be used, such as the Stroop task (Stroop, 1935). If a significant relationship is found between self-reported pain and a high attention demanding test like the Stroop, it would provide a stronger argument for the proposed rationale that the magnitude of the pain-cognition relationship is partly moderated by the level of inhibitory control.

Using a computer may have resulted in an inaccurate assessment of a participant's cognitive ability. One of the benefits for using a computer was the ability to record a precise reaction time response. As a result, it would not be beneficial to exclude the laptop computer. Rather, prior to beginning any actual cognitive assessments the participant must undergo a very specific training protocol on how to use the computer for the cognitive tests. Once the participant displays that they fully understand how to use the designated laptop they then should be scheduled for their pretest assessment.

It was also suggested that the 2-Back test was significantly more difficult than the 1-Back test, which is already considered a fairly difficult task. It is important to note that the 2-Back test was the last test administered in the cognitive battery. It could be the case the already difficult task became even more difficult as a result of testing fatigue. Consequently, the current study was unable to obtain an accurate assessment of a participant's higher order working memory performance. One remedy for this situation is counterbalancing the order of the cognitive tests to control for order effects within a testing session.

In regards to the assessment of stress, the DISE should be used at every testing to assess the impact of current stressors and its relationship between pain and cognitive performance. In addition, rather than creating a composite score the extent to which stress moderates the pain-cognition relationship should be assessed for each stressor as suggested by Rosnick and colleagues (2007). By examining each stressor individually the experimenter may be able to tap into which type stressors (e.g. an argument or a workplace stressor) are uniquely associated with self-reported pain and cognition. Furthermore, it might be beneficial to include a question that asks whether there are intrusive thoughts relating to that stressor. This would allow for both the uniqueness of each type of stressor and the extent to which each stressor leads to intrusive thoughts

The rationale for examining the effect of negative affect on self-reported pain was based upon findings relating to the relationships between pain, cognition, and depression. Unfortunately, the current study assessed depression only at the pretest, therefore a proxy measure (PANAS-Negative Affect) of depressive symptoms was used. Furthermore this assessment was not designed to assess changes in depressive symptoms over relative short periods of time. Consequently, future studies should attempt to incorporate a measure that is sensitive to daily changes in depressive symptoms in addition to the PANAS-Negative Affect composite.

The current study required a large commitment of each participant's time (e.g. 1-2 hour battery and 8-45 minute testing sessions) and consequently, 14 participants dropped out of the study. Future studies should make attempts to either shorten each assessment battery and/or increase the incentives for participants to completing the entire study. It is important to note that the findings from the current study suggest that the pain-cognition relationship should be examined over multiple time points. Subsequently, experimenters should not attempt to shorten the time commitment by assessing this relationship at only one time point.

Finally, future studies should implement a more multidimensional measure of self-reported pain. It could be the case that the lack of findings was due to an incomplete assessment of pain. Examples of commonly used multidimensional pain measures that could be used in future studies are the McGill Pain Questionnaire (MPQ; Melzack, 1975) or the Multidimensional Pain Inventory (MPI; Kerns, Turk, & Rudy, 1985).

Conclusion

Inconsistencies in the research literature have been found in the extent to which self-reported pain is related to cognitive performance. The current study attempted to remedy some of these inconsistencies by examining the relationship in a heterogeneous sample of community-dwelling older adults. Unfortunately, a strong relationship between self-reported pain and cognitive performance was not found. In previous research, the relationship is generally found in clinical or chronic pain patients who seek medical help due to debilitating levels of pain. Perhaps only when pain reseaches a clinical threshold either in intensity of duration that effects on cognition can be observed.

Even though a strong direct link between self-reported pain and cognition was not found, the most noteworthy findings were related to the moderators. A significant moderating effect was found at the between person level (e.g. self-reported pain X negative affect for Complex Reaction Time). In contrast multiple moderating effects were found at the within-person level. The lack of findings at the between-person level may not be so surprising; since it has been suggested that to fully understand how pain is related to constructs such as cognition, the relationship should be assessed at multiple time points (Zautra, 2001). The lack of convergence for the between and within-person analysis supports the current thinking in the aging literature that many of the between person relationships might not be accurate reflections of within-person processes (e.g., Sliwinski et al., 2007; Sliwinski & Buschke, 2004). Recall that the current investigation found significant occasion-to-occasion fluctuations in self-reported pain and cognition, which suggests that self-reported pain and cognition are clearly not static constructions. Rather, they are dynamic processes that occur within the individual and should be studied as such.

Additionally, fluctuations in self-reported pain, in conjunction with stress and negative affect were related to fluctuation in some of the cognitive abilties. These coupling relationships suggest that perhaps in clinical settings when an older adult reports expereincing pain, it is important to assess whether the indiviudal is also expericing negative affect and stress. As suggested by the current study's results, the expereince of both pain and negative affect/stress can be more detrimental to an individual's level of daily cognitive functioning than just experiencing pain alone. Thus, the current study highlights the need for further exploration in the association between self-reported pain and cognitive functioning and how other comorbid health illnesses may influence this relationship particularly within older-old adults. Although generally, it was found that the presence of pain in conjunction with negative affect/stress was detrimental to performance, there were some cases where the concurrent presence of these factors actually facilitated cognitive performance. Furthermore, there was some evidence that the level of inhibitory control played an additional role in the magnitude of the relationship between self-reported pain and cognitive functioning. In sum, while not particularly uniform, these findings suggest that stress and negative affect play a role in the pain-cognition relationship, and that an examination of this relationship among "healthy" community-dwelling older adults is more complex compared to what has previously been found in clinical populations.

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APPENDIX

Appendices Contents

Appendix A

Self-reported Pain Questionnaire

(1) How much BODILY pain have you had during the past 12 hours?

1	2	3	4	5	6
None	Very Mild	Mild	Moderate	Severe	Very Severe

(2) During the past 12 hours, how much did PAIN interfere with your normal

work (including both work outside the home and housework)?

1	2	3	4	5
Not at all	A little bit	Moderately	Quite a bit	Extremely

(2a**)** If you have experienced pain in the past 12 hours please indicate the location of your pain by circling all the bodily locations that apply:

Neck	Elbows	Hips	Feet/Toes
Back	Wrists	Knees	Shoulders
Hand/Fingers	Ankles	Other__________________________	

Appendix B

Self-Report of Physical Health Problems Questionnaire

We are now going to ask you a number of questions regarding your health. Please read each question carefully and choose the response you think is best:

Have you ever been told by a doctor or nurse that you have:

1. Diabetes	( )Yes	When___________	( )No
2. Cardiovascular/heart disease	( )Yes	When___________	( )No
3. High Blood Pressure	( )Yes	When___________	( )No
4. Arthritis:	( ) Yes	When______________	( ) No

if yes, in what part of your body? Hands Back Knees Hips Elbows

Other____________ (Circle all that apply)

5. Has a doctor or nurse ever told you that you have/had:

( ) Broken Hip..if so when?_______
( ) A Stroke..if so when?_______
( ) A Heart Attack...................................if so when?_______
( ) Angina...if so when?_______
( ) Circulation Problems..........................if so when?_______
( ) Asthma...if so when?_______
( ) Gout...if so when?_______
( ) Gallbladder trouble............................if so when?_______
( ) Stomach ulcers..................................if so when?_______
( ) Thyroid trouble...................................if so when?_______
( ) Tuberculosis (TB)...............................if so when?_______
( ) Kidney Trouble...................................if so when?_______
( ) Cancer...if so when?_______

Appendix C

PANAS

Please indicate the extent to which you have experienced the following emotions in the **last 24 hours** by selecting a choice from those presented.

interested
1 Not at all 2 A Little 3 Quite a bit 4 Very much
distressed
1 Not at all 2 A Little 3 Quite a bit 4 Very much
excited
1 Not at all 2 A Little 3 Quite a bit 4 Very much
upset
1 Not at all 2 A Little 3 Quite a bit 4 Very much
strong
1 Not at all 2 A Little 3 Quite a bit 4 Very much
guilty
1 Not at all 2 A Little 3 Quite a bit 4 Very much
scared
1 Not at all 2 A Little 3 Quite a bit 4 Very much
hostile
1 Not at all 2 A Little 3 Quite a bit 4 Very much
enthusiastic
1 Not at all 2 A Little 3 Quite a bit 4 Very much
proud
1 Not at all 2 A Little 3 Quite a bit 4 Very much
irritable
1 Not at all 2 A Little 3 Quite a bit 4 Very much
alert
1 Not at all 2 A Little 3 Quite a bit 4 Very much
ashamed
1 Not at all 2 A Little 3 Quite a bit 4 Very much
inspired
1 Not at all 2 A Little 3 Quite a bit 4 Very much
nervous
1 Not at all 2 A Little 3 Quite a bit 4 Very much
determined
1 Not at all 2 A Little 3 Quite a bit 4 Very much
attentive
1 Not at all 2 A Little 3 Quite a bit 4 Very much
jittery

1 Not at all 2 A Little 3 Quite a bit 4 Very much
active
1 Not at all 2 A Little 3 Quite a bit 4 Very much
afraid
1 Not at all 2 A Little 3 Quite a bit 4 Very much

Appendix D

Elders Life Stress Inventory

Please read each that follows. If you did not experience it, DURING THE PAST YEAR, push the bottom "1", if you did experience it indicate how stressful it was for you by selecting the response that reflects how stressful it was for you.

Deterioration of memory 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Death of spouse 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Institutionalization of spouse 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Death of a son or daughter 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Death of a parent 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Death of other close family member 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Major personal injury or illness 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Retirement 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Divorce 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Major deterioration in financial state 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Marital separation 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Marriage 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Death of a friend 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful

Major deterioration in health or behavior of a family member 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Major decrease in activities that you really enjoyed 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Child's divorce or marital separation 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Decrease in responsibilities or hours at work or where you volunteer 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Increase in responsibilities or hours at work or where you volunteer 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Move to a less desirable residence 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Change to a less desirable line of work 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Spouse retired 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Deterioration in living conditions 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Troubles with boss or co-workers 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Worsening relationship with a child 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Worsening relationship with your spouse 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Assuming major responsibility for a parent 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Loss of a very close friend due to a move or break in friendship 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Being burglarized or robbed 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful
Loss of prized possessions due to move 1 did not occur 2 not at all stressful 3 a little stressful 4 somewhat stressful 5 very stressful 6 extremely stressful

Appendix E

Daily Inventory of Stressful Events

The next set of questions asks about stressful experiences that may have happened to you in the past 24 hours.

1. In the last 24 hours, did you have an argument or disagreement with anyone?

______ NO ______ YES

NO YES

a. Who was it with?
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. What was the main topic of the argument?
- _____ Money/Financial Issues
- _____ Family obligation/responsibilities
- _____ Household-related tasks
- _____ Work /Volunteer-related tasks
- _____ Scheduling
- _____ Other ____________________

c. How stressful was this for you?

___ Not At All __A Little __ Somewhat __Very

d. How much control do you feel you had over this situation?

___ None __A Little __ Some __ A lot

e. Is the issue resolved? __ No __ Yes

2. In the last 24 hours, did anything happen (other than what you have already mentioned) that you could have argued or disagreed about, but you decided to let it pass?

______ NO ______ YES

NO YES

a. Who was it with?

- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. What was the main topic of the potential argument or disagreement?

- _____ Money/Financial Issues
- _____ Family obligation/responsibilities
- _____ Household-related tasks
- _____ Work /Volunteer-related tasks
- _____ Scheduling
- _____ Other ____________________

c. How stressful was this for you?

___ Not At All __A Little __ Somewhat __Very

d. How much control do you feel you had over this situation?

___ None __A Little __ Some __ A lot

e. Is the issue resolved? __ No __ Yes

3. In the last 24 hours, did anything happen in your workplace or volunteer setting (other than what you have already mentioned) that most people would consider stressful?

______ NO ______ YES

NO YES

a. Who else was involved?
- ___ No one else
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Co-worker
- ___ Someone Else ____________________

b. Was there and argument or disagreement?
___ No ___ Yes

c. What was the main source of the stress?
- _____ Income or job security
- _____ Mistakes
- _____ Having too much to do
- _____ Scheduling
- _____ Other ____________________

d. How stressful was this for you?
___ Not At All __A Little __ Somewhat __Very

e. How much control do you feel you had over this situation?
___ None __A Little __ Some __ A lot

f. Is the issue resolved? __ No __ Yes

Continue on to next question

4. In the last 24 hours, did anything happen at home (other than what you have already mentioned) that most people would consider stressful?

______ NO ______ YES

NO YES

a. Who else was involved?
- ___ No one else
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. Was there and argument or disagreement?
___ No ___ Yes

c. What was the main source of the stress?
- _____ Household maintenance
- _____ Neighborhood concerns
- _____ Having too much to do
- _____ Scheduling conflicts
- _____ Financial issues
- _____ Pet problems
- _____ Other ____________________

d. How stressful was this for you?
___ Not At All __A Little __ Somewhat __Very

e. How much control do you feel you had over this situation?
___ None __A Little __ Some __ A lot

f. Is the issue resolved? __ No __ Yes

Continue on to next question

5. In the last 24 hours, did anything happen <u>to a close friend or relative</u> (other than what you have already mentioned) that turned out to be stressful for you?

______ NO ______ YES

NO YES

a. What relation is this person to you?
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. What happened to this person?
- _____ Financial problem
- _____ Legal problem
- _____ Health or safety issue
- _____ Work-related issue
- _____ Death
- _____ Emotional problem
- _____ Relationship problem
- _____ Other ____________________

c. How stressful was this for you?

___ Not At All __A Little __ Somewhat __Very

d. How much control do you feel you had over this situation?

___ None __A Little __ Some __ A lot

e. Is the issue resolved? __ No __ Yes

Continue on to next question

6. In the last 24 hours, did anything stressful happen (other than what you have already mentioned) <u>regarding your personal health</u>?

______ NO ______ YES

NO YES

a. <u>Who</u> else was involved?
- ___ No one else
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. What was the <u>main problem</u>?
- _____ Accident
- _____ Potential accident
- _____ Medication-related issue
- _____ Health insurance issue
- _____ Illness
- _____ Receiving treatment
- _____ Problems during health care visit
- _____ Other ____________________

c. How <u>stressful</u> was this for you?
___ Not At All __A Little __ Somewhat __Very

d. How much <u>control</u> do you feel you had over this situation?
___ None __A Little __ Some __ A lot

e. Is the issue resolved? __ No __ Yes

Continue on to next question

7. In the last 24 hours, did anything else happen (other than what you have already mentioned) that most people would consider stressful?

______ NO ______ YES

NO YES

a. Who else was involved?
- ___ No one else
- ___ Spouse
- ___ Your Child(ren)
- ___ Your Grandchild(ren)
- ___ Other Family Member
- ___ Friend
- ___ Neighbor
- ___ Co-worker
- ___ Someone Else ____________________

b. Was there an argument or disagreement?
___ No ___ Yes

c. What was the main source of the stress?
- _____ Weather
- _____ Traffic/transportation
- _____ Political
- _____ News event
- _____ Mistakes/confusion
- _____ Ethical/moral conflict
- _____ Other ____________________

d. How stressful was this for you?
___ Not At All __A Little __ Somewhat __Very

e. How much control do you feel you had over this situation?
___ None __A Little __ Some __ A lot

f. Is the issue resolved? __ No __ Yes

Continue on to next question