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Task-switching Ability Protects against the Adverse Effects of Pain on Health: A Longitudinal Study of Older Adults

Ian A. Boggero, M.S.*

University of Kentucky, Department of Psychology, 111-B Kastle Hall

Tory Eisenlohr-Moul, Ph.D., and

University of Kentucky, University of North Carolina at Chapel Hill, Department of Psychiatry, Medical School Wing D

Suzanne C. Segerstrom, Ph.D.

University of Kentucky, Department of Psychology, 012 J Kastle Hall

Abstract

Objective—Aging is often accompanied by increases in pain, which may threaten physical health. Successfully managing increased pain requires the ability to switch attention away from the pain and toward adaptive health cognitions and behaviors. However, no study to date has tested how pain interacts with task-switching ability to predict future health in older adults. Additionally, no study has tested whether objective (i.e., task-switching performance) or subjective measures of cognitive ability have a stronger impact on future health.

Design/Methods—The current study tested these interactions in community-dwelling older adults. Participants included 150 older adults who provided pain, task-switching ability, subjective cognitive functioning, and health data every 6 months for up to 5 years.

Results—Multilevel modeling was used to analyze the data, yielding gamma (γ) analogous to unstandardized beta weights in regression. A significant interaction between task-switching and pain indicated that when task-switching ability was lower than usual, higher than usual pain predicted poorer health at the following wave ($\gamma = 0.30$, $SE = .12$, $t(663) = 2.45$, $p = .009$; 95% CI: .07 – .65). When task-switching ability was higher than usual, there was no effect of pain on health ($\gamma = -0.13$, $t(663) = -.85$, $p = .39$; 95% CI: $-.44 - .17$). No significant interaction was found for subjective cognitive functioning.

Conclusions—Objective task-switching ability, but not subjective cognitive functioning, may have health-protective effects when older adults experience increases in pain.

Keywords

Executive functioning; Interleukin-6; beta-2 microglobulin; pain; older adults

*Correspondence should be addressed to Ian Boggero, M.S.; University of Kentucky, Department of Psychology; 111-B Kastle Hall; Lexington, KY 40506; ian.boggero@uky.edu; (859) 257-2207.

Introduction

Aging is accompanied by increases in physical pain (Gagliese, 2009; Reyes-Gibby, Aday, & Cleeland, 2002), and older adults experience pain more frequently than younger adults (Soares, Sundin, & Grossi, 2003). Cross-sectionally, pain is associated with more physical complaints and poorer health (Demmelmaier, Åsenlöf, Lindberg, & Denison, 2010; Kroenke, Johns, Theobald, Wu, & Tu, 2013; Reyes-Gibby et al., 2002). Pain may impact health through a number of pathways including physical activity, sleep, fatigue, and inflammation, among other mediators (e.g., Boggero, Kniffin, de Leeuw, & Carlson, 2013; Koffel et al., 2015; van den Berg-Emons, Schasfoort, de Vos, Bussmann, & Stam, 2007; Watkins, Maier, & Goehler, 1995). Yet, main effects associating higher pain with poorer health outcomes mask the possibility that older adults may be able to cope with daily pain better at some times than others, with consequences for health. These within-person fluctuations in ability to cope with pain are the primary focus of the current study.

Cognitive functioning is an important psychological resource that allows people to adaptively cope with pain (Moriarty, McGuire, & Finn, 2011; Solberg Nes, Roach, & Segerstrom, 2009). Pain demands cognitive resources, leaving fewer cognitive resources for other uses (Eccleston and Crombez, 1999; Oosterman, Dijkerman, Kessels, & Scherder, 2010; Verhoeven et al., 2011). However, cognitive resources are required to appropriately respond to pain, whether to remember to take medications, maintain social activities, or perform a number of other health-adaptive behaviors (Insel, Morrow, Brewer, & Figueredo, 2006; Solberg Nes et al., 2009). Unfortunately, aging is accompanied not only by pain but also by objective declines in cognitive functioning (Ponds, Van Boxtel, & Jolles, 2000; Salthouse, 2010), putting older adults at particular risk of experiencing negative health consequences of pain.

One specific aspect of cognitive functioning that has been shown to be important for managing pain is task-switching ability, defined as the ability to “switch back and forth between multiple tasks, operations, or mental sets” (Miyake et al., 2000, p. 55). It is sometimes called “attention-switching,” “set-shifting,” or “switching,” and is positively correlated with, but separable from, cognitive inhibition and mental updating (Miyake et al., 2000). Task-switching allows people to effectively self-regulate thoughts and actions by allowing them to shift from less adaptive sets (e.g., ruminating about pain) to more adaptive ones (e.g., planning and performing adaptive activities in spite of pain; for a review, see Suchy, 2009).

In support of the hypothesis that task-switching is important for managing pain, better task-switching ability predicted less pain at 6 and 12 months following knee or breast cancer surgery (Attal et al., 2014). In both a rheumatoid arthritis sample and a community-dwelling older adult sample, pain was inversely related to task-switching ability ($r = -.17$ and $r = -.42$, respectively; Abeare et al., 2010; Karp et al., 2006). In laboratory studies, participants with better task-switching more effectively distracted themselves from painful stimuli (Verhoeven et al., 2011). Additionally, poorer task-switching prospectively predicted worse chronic disease management in older adults with diabetes (Munshi et al., 2006). Taken together, evidence suggests that task-switching ability is particularly important for

successfully managing pain. Because increases in pain have been linked to poor health (Demmelmaier et al, 2010; Di Bonaventura, Gupta, McDonald, & Sadosky, 2011; Kroenke et al., 2013; Reyes-Gibby et al., 2002), better task-switching may be important for maintaining health in the presence of pain.

Aging is also accompanied by subjective declines in cognitive functioning. Older adults report feeling that their mental abilities have decreased over time (Martin & Zimprich, 2003; Newson & Kemps, 2006; Ponds et al., 2000). Several large studies have found no or small correlations between objective and subjective cognitive functioning, suggesting that people's opinions about their own mental functioning are not predictive of actual cognitive performance (Cook & Marsiske, 2006; Newson & Kemps, 2006). Despite their dissociation from objective performance, subjective ratings of cognitive functioning correlate with daily behaviors and subjective ratings of health (Ponds et al., 2000). No study to date has tested whether pain interacts with objective task-switching ability or subjective cognitive functioning to predict future health.

The Current Study

The current study tested whether pain interacted with objective task-switching ability or subjective cognitive functioning to influence health in community-dwelling older adults. The hypotheses of the current study were derived from a model in which pain is a trigger for psychological and physiological changes that (1) can be directed or modified using task-switching ability and (2) have broad implications for health. The study particularly focused on within-person fluctuation.

The current study utilized a broad composite measure of health consisting of self-rated health (Ware & Sherbourne, 1992), chronic disease severity (Clark, von Korff, Saunders, Baluch, & Simon, 1995), and inflammatory biomarkers (Harris et al., 1999). These specific components of the composite were chosen because they all reflect the general health of the person and prospectively predict morbidity and mortality (Clark et al., 1995; DeSalvo, Bloser, Reynolds, He, & Muntner, 2006; Volpato et al., 2001). This composite has the advantage of being a multimodal assessment of general health, consisting of self-report, medication use, and biomarkers, thus allowing it to capture health better than any one component alone.

The primary hypothesis of the current study was that when people reported higher than usual levels of pain and had lower than usual task-switching performance, they would report poorer health 6 months later. A secondary hypothesis was that these relationships would be present but weaker for subjective cognitive functioning than for objective task-switching ability, as subjective cognitive functioning may not influence how well people respond to pain but has previously been correlated with subjective health (Ponds et al., 2000).

Materials and Methods

Participants

Participants were 150 community-dwelling, married older adults recruited from a research registry maintained by the Center on Aging at the university where the study was conducted. Data utilized in the current study are from 10 semi-annual waves of an ongoing longitudinal study testing the relationships between thoughts, stress, and immune function in older adults. To be eligible, participants had to be willing to undergo influenza vaccination and venipuncture; not be on any steroid, opiate, or other immunomodulatory medication; not have received chemotherapy or radiation therapy within the last five years; and not be taking more than 2 of the following classes of medications: psychotropics, antihypertensives, hormone replacement, or thyroid supplements. To avoid violations of independence, only one participant per household was allowed. The sample consisted of 87 females (58%). At the first wave of data collection, mean age was 74.0 ($SD = 6.1$) and mean BMI was 27.63 ($SD = 4.87$). Self-reported ethnicities were white (96%) and African-American (4%). The median annual household income for the sample was \$60,000 (range \$12,000 – \$400,000), and median years of education was 16 (range = 7 – 22). Existing health conditions were consistent with expectations for a sample of community-dwelling older adults: hypertension (71% of person-waves), hyperlipidemia (50%), heart disease (39%), Parkinson's disease (19%), thyroid disease (13%), vascular disease (12%), respiratory disease (12%), inflammatory pain (11%), and diabetes (10%).

Procedures

Participants were assessed every six months for up to 10 waves. Wave 1 interviews took place in 2006–2007, and interviews continued through 2011. At each wave, graduate students in clinical psychology interviewed participants in their homes. Participants completed a battery of questionnaires and a task-switching task, as described below. To assess inflammatory status, serum IL-6 and $\beta 2\mu$ were measured. A phlebotomist obtained a blood sample from each participant in the fall and spring of each year, pre- and post-influenza season. IL-6 and $\beta 2\mu$ measurements were matched to the closest preceding interview wave. The average interval between interview visits and serum sample collection for a given wave was 49 days. Participants were paid \$20 at each interview. All study materials and procedures were approved by the Institutional Review Board.

Complete pain, task-switching, health, and subjective cognitive functioning data were available for 139 participants at Wave 1; 127 at Wave 2, 119 at Wave 3, 111 at Wave 4, 96 at Wave 5, 96 at Wave 6, 82 at Wave 7, 79 at Wave 8, 44 at Wave 9, and 25 at Wave 10, yielding a total of 918 complete person-waves for analysis. Missing data from participants enrolled in the study accounted for 199 missing waves; additionally, data were missing at later waves due to dropout ($n = 65$; 336 missing waves) and death ($n = 6$; 47 missing waves). Missing data numbers at Waves 8, 9, and 10 were affected by the date of the Wave 1 interview (i.e., participants who enrolled later completed fewer waves before study end; 76 missing waves). Figure 1 presents a flow chart of data accrual.

Measures

Demographics—At Wave 1, participants provided information on their age, sex, family income, education level, and ethnicity.

Task-Switching—At each wave, participants completed the Trail Making Test (TMT), which includes Parts A and B. In Part A, participants drew lines connecting numbers in sequential order from smallest to largest while being timed by the experimenter. In Part B, participants performed the same task with the added challenge of alternating between numbers and letters. Errors were immediately corrected by the experimenter and are reflected in the time of completion. Part A draws on psychomotor speed and visual perception. Part B also draws on these abilities but has the added challenge of switching back and forth between numbers and letters—a task that draws on task-switching ability (Sanchez-Cubillo et al., 2009). The difference in completion time between Parts A and B isolates task-switching ability challenged only in Part B from psychomotor speed and visual perception abilities challenged in both Parts A and B (Sanchez-Cubillo et al., 2009). This difference isolates task-switching ability (e.g., Perianez et al., 2007). In the current study, the difference measure was taken as time on Part A minus time on Part B, so less negative numbers (i.e., closer to 0) reflected less additional difficulty with Part B and better task-switching.

Subjective Cognitive Functioning—To assess subjective cognitive functioning at each wave, the cognitive functioning scale from the Medical Outcomes Study was used (Ware & Sherbourne, 1992). Participants rated the extent to which they perceived six different cognitive problems over the past month using a scale ranging from 1 ‘All of the time’ to 6 ‘None of the time,’ with higher scores representing better perceived cognitive functioning. Using equations provided by Cranford et al. (2006), it was estimated that subjective cognitive functioning was reliable between individuals ($R_{1F} = .89$) and within individuals across waves ($R_C = .72$).

Pain—As part of the parent study, participants completed a daily health behavior questionnaire assessing pain and 12 other health behaviors (e.g., smoking, diet, exercise) on three evenings at each wave. For the current study, only the pain item was analyzed. On each of the three evenings, participants reported their current level of pain relative to their usual level of pain, using a 100 point scale. They were instructed to report a score of 50 if their pain was at the usual level. Scores between 50 and 100 correspond to higher-than-usual levels of pain, and scores between 0 and 50, to lower-than-usual levels of pain. Responses were averaged across all 3 evenings at each wave, and the average response was divided by 10 so that a 1-unit change in pain would equal a 10-unit change in pain on the 0–100 scale. This aggregated wave-level measure of pain was reliable between individuals ($R_{1F} = .87$), and within individuals across waves ($R_C = .74$).

Although this measure of pain is unconventional, it is ideal for assessing within-person changes in pain because it allows for the capability to report the same amount change in either direction regardless of “usual” pain levels. Thus, the problem of restricting range in pain fluctuations for those who were already high in pain was avoided (e.g., someone with

an absolute pain of 80 could only report a 20 point increase in pain but an 80 point decrease in pain using absolute pain levels).

III Health—To measure health, a composite variable was created using the following subjective and objective markers. All the components of the composite (1) reflect the general health of the person and (2) prospectively predict morbidity and mortality (Clark et al., 1995; DeSalvo et al., 2006; Volpato et al., 2001). To create the composite health variable, Z-scores were computed for each of the elements and averaged. The composite health variable was reliable between individuals ($R_{IF} = .90$) and within individuals across waves ($R_C = .81$). The variable is scored such that higher scores indicate poorer health.

Chronic Disease Score: The Chronic Disease Score (CDS) is a measure of chronic diseases severity calculated from weighted demographic and pharmacy data (Clark et al., 1995). Weighted pharmacy data, age, and sex yielded a disease score that predicted total medical costs and correlated strongly with mortality, hospitalizations, self-rated health, and self-reported disability (Clark et al., 1995; Putnam et al., 2002). At each wave, participants provided a list of their current prescription medications. These medications were coded into separate medication classes, and each medication class was multiplied by its empirically derived weight. Higher CDS scores reflected greater chronic disease severity. To avoid criterion contamination with the pain predictors, CDS was computed without the pain and inflammation and pain medication classes. Likewise, to avoid having overlapping predictors and dependent variables, CDS was computed without the gender and age adjustments. Inclusion of these variables did not affect the results of any analyses; thus, to enhance interpretability, only data from the CDS without pain, inflammation, gender, or age components are reported.

Inflammatory Biomarkers: IL-6 and $\beta 2\mu$: Interleukin-6 (IL-6) and beta-2-microglobulin ($\beta 2\mu$) were used as biomarkers of inflammation. IL-6 is a proinflammatory cytokine (a class of small proteins secreted by T-cells and macrophages to produce an inflammatory response), and its level in blood is a widely accepted indicator of systemic inflammation (Clark, 2008). $\beta 2\mu$ is a protein expressed on the surface of immune cells as part of the histocompatibility complex (Clark, 2008). Activated cells express more $\beta 2\mu$ and shed it into the bloodstream at higher rates; as such, it is a good indicator of cellular immune activation. $\beta 2\mu$ in the bloodstream is higher in individuals with viral infection, cancer, and other chronic inflammatory disorders (Bethea & Forman, 1990; Cooper & Plesner, 1980). $\beta 2\mu$ is also elevated in those with chronic inflammatory disorders compared with healthy controls, suggesting that it is a valid inflammatory biomarker (Amighi et al., 2001; Buchwald, Wener, Pearlman, & Kith, 1997; Yilmaz, Köklü, Yüksel, & Arslan, 2014).

Sera were frozen at -80°C and analyzed in annual batches to avoid confounding participants with batch. Analyses were conducted using high-sensitivity ELISA kits for IL-6 (R&D Systems, Minneapolis, MN). Mean intra-assay coefficient of variance for all IL-6 assays was 1.9% and the mean inter-assay coefficient of variance was 4.5%. IL-6 results were log-10 transformed to improve normality. Serum IL-6 has good generalizability over a period of several weeks in older adults (Rao, Pieper, Currie, & Cohen, 1994) and so was expected to be measured from single assessments with adequate reliability. $\beta 2\mu$ was assessed

using ALPCO (Salem, NH) diagnostic $\beta 2\mu$ immunoassay kits. Mean intra-assay coefficient of variance for all $\beta 2\mu$ assays was 2.9% and the mean inter-assay coefficient of variance was 3.9%. Inflammatory marker data for waves at which individuals were currently suffering from acute infection ($n = 8$), cancer ($n = 2$), or had undergone surgery requiring hospitalization in the past 6 months ($n = 6$) were removed.

Self-Rated Health: A single item from the Medical Outcomes Study (Ware & Sherbourne, 1992) was used to assess self-rated health. Participants completed the item ‘in general, would you say your health is...’ using a 5-point Likert scale ranging from 1 ‘excellent’ to 5 ‘poor.’ Higher scores reflected worse self-rated health (the same direction as the other health variables). Self-rated health is a good predictor of mortality, with those reporting “poor” health having a two-fold increase in mortality risk relative to those reporting “excellent” health (DeSalvo et al., 2006).

Data Analytic Plan

Data were analyzed using multi-level models in SAS PROC MIXED. Multilevel modeling is a statistical technique used for nested data, where observations are not independent. In the current study, waves (Level 1) were nested within people (Level 2), as a person’s responses at one wave were not independent from his or her responses at another. These models utilized all available data with no listwise deletion, accommodating different amounts of missing data. Task-switching and subjective cognitive functioning were centered to isolate the between-person and within-person components. That is, each was decomposed into two variables: (1) the person’s mean score across all waves, a Level 2 variable, and (2) the person’s deviation from his/her own mean score at each wave, a Level 1 variable. The Level 1 pain variable was centered around 50 so that values above zero represented higher than usual levels of pain for that person. Age was centered around the sample mean. Sex was scored such that female was equal to 1 and male was equal to 0. Composite ill health values were multiplied by 100 in order to increase interpretability of results.

Level 1 predictors (pain, task-switching, and cognitive functioning deviations) were modeled such that (ill) health at wave X was predicted by within-person deviations in these predictors at wave X-1. The effect of each predictor was reported with the gamma weight (analogous to an unstandardized beta in regression) for that predictor. Outcomes were standardized with a mean of 0 and SD of 100 (as a consequence of multiplying the health variable by 100). The covariates sex, age, and standardized BMI were selected on the basis of (1) their robust relationships with health and (2) the fact that they were not hypothesized to play a substantive (e.g., mediational) role in the model (Segerstrom & Smith, 2012).

The first model tested whether the composite health variable was predicted by covariates (age, sex, and BMI), prior wave-level pain, prior wave-level deviations in task-switching ability, and the interaction of prior wave-level pain with prior wave-level deviations in task-switching ability. The multi-level model was constructed as shown in Model 1 below for person j at wave i , where TS is task-switching ability:

$$\text{Health}_{i,j} = \beta_{0,j} + \beta_{1j} * \text{pain}_{i-1,j} + \beta_{2j} * \text{TS}_{i-1,j} + \beta_{3j} * \text{pain}_{i-1,j} * \text{TS}_{i-1,j} + e_{i,j}$$

Health at wave i was a function of person j 's intercept ($\beta_{0,j}$), effects of pain and deviations in task-switching at the previous wave ($\beta_{1,j}$, $\beta_{2,j}$, $\beta_{3,j}$), and unexplained variance ($e_{i,j}$).

$$\beta_{0,j} = \gamma_{0,0} + \gamma_{0,1} * \text{age}_j + \gamma_{0,2} * \text{sex}_j + \gamma_{0,3} * \text{BMI}_j + \gamma_{0,4} * \text{TS}_j + U_{0,j}$$

Differences between people across waves were a function of the sample intercept ($\gamma_{0,0}$), effects of age, sex, BMI, and mean task-switching ($\gamma_{0,1}$, $\gamma_{0,2}$, $\gamma_{0,3}$, $\gamma_{0,4}$), and unexplained variance ($U_{0,j}$).

$$\begin{aligned}\beta_{1,j} &= \gamma_{1,0} \\ \beta_{2,j} &= \gamma_{2,0} + U_{2,j} \\ \beta_{3,j} &= \gamma_{3,0}\end{aligned}$$

Using -2 log likelihood as a deviance statistic to determine the incremental improvement in model fit, a significant improvement in fit was obtained when within-person deviation in task switching was added as a random predictor ($\chi^2(1/2) = 987.9$, $p < .001$), suggesting that there existed significant variability in the extent to which within-person deviations in task-switching predict ill health; this finding is consistent with the presence of moderation. Model fit was not significantly improved with the inclusion of a random effect of within-person deviations in pain. Therefore, effects of task-switching at Level 1 were treated as random. Effects of pain and the interaction of pain and task-switching at Level 1 were treated as fixed. A second, identical model substituted prior-wave subjective cognitive functioning for prior-wave task-switching ability. Model fit was significantly improved with a random effect of subjective cognitive functioning, but not with a random effect of pain; therefore, effects of subjective cognitive functioning at Level 1 were treated as random. Post-hoc power analyses using observed intraclass correlations and equations from Snijders and Bosker (1999) revealed that the present study achieved 80% power to detect a conventionally small effect (N adjusted for design effect = 157.78; smallest detectible effect size: $r = .13$).

Results

Descriptive Statistics

Bivariate correlations among study variables at each of the 10 waves can be found in the supplemental online material. For pain, task-switching, cognitive functioning, and health variables, intercepts from null models (i.e., models with no predictors) were used to estimate the sample means of model variables (Singer & Willett, 2003). Table 1 lists null model intercepts and intraclass correlation coefficients (ICC) for within-person variables. ICCs measure the correlation between observations within the same person; for example, an ICC of .40 for task switching ability reveals that the average correlation among all waves *within* a specific person was .40. A preliminary model was fit to characterize the trajectory of composite health scores over time across the study. Consistent with the expected effects of aging on physical health, ill health increased over time (γ for Wave = 2.72, $SE = 0.47$, $t(839) = 5.75$, $p < .0001$; 95% CI: 1.79 – 3.65).

Multilevel Models Predicting Changes in Health

In the first model, we tested whether within-person deviations in task-switching performance interacted with pain to predict future health. Results are presented in Table 2. Poorer health was predicted by older age ($\gamma = 3.23$, $SE = .84$, $t(124) = 3.83$, $p < .001$; 95% CI: 1.56 – 4.90) and higher BMI ($\gamma = 4.45$, $SE = 0.99$, $t(124) = 4.48$, $p < .001$; 95% CI: 2.48 – 6.42). That is, for a 1-year change in age, there was a change of 3.23 in the direction of poor health, and for each unit change in BMI, there was a change of 4.45 in the direction of poor health. After correcting for the fact that we multiplied the health score by 100, these values corresponded to a .03 and a .04 standard deviation increase in the direction of poor health for each unit increase in age and BMI, respectively.

Consistent with our prediction, there was a significant interaction between prior wave-level pain and prior wave deviations in task-switching (Interaction $\gamma = -0.03$, $SE = 0.011$, $t(663) = -2.72$, $p = .007$; 95% CI: $-.15 - -.008$). Specifically, when task-switching ability was higher than usual at the prior wave (1 SD above an individual's mean task-switching ability), higher than usual pain at the previous wave was not associated with health ($\gamma = -0.13$, $SE = 0.15$, $t(663) = -.85$, $p = .39$; 95% CI: $-.44 - .17$). When task-switching ability was lower than usual at the prior wave (1 SD below an individual's mean task-switching ability), higher than usual pain at the previous wave predicted *poorer* health ($\gamma = 0.30$, $SE = .12$, $t(663) = 2.45$, $p = .009$; 95% CI: $.07 - .65$; see Figure 2 for a depiction of the interaction).

In the second model, we tested whether within-person deviations in subjective cognitive functioning interacted with pain to predict future health. Results are presented in Table 3. Poorer health was predicted by older age ($\gamma = 3.68$, $SE = .82$, $t(124) = 4.48$, $p < .001$; 95% CI: 2.06 – 5.38) and higher BMI ($\gamma = 4.42$, $SE = .96$, $t(124) = 4.60$, $p < .001$; 95% CI: 2.52 – 6.33). There were no significant main effects of deviations in self-reported cognitive functioning, and the interaction between changes in self-reported cognitive functioning and prior-wave pain was not significant (Interaction $\gamma = -0.15$, $SE = 0.18$, $t(681) = -.83$, $p = .41$; 95% CI: $-.52 - .21$).

Discussion

Using a longitudinal dataset of community-dwelling older adults, we found that within-person changes in pain and task-switching ability interacted to predict health at a subsequent wave. Specifically, when participants reported higher than usual pain, lower than usual task-switching ability predicted poorer health at the next wave. The relationship between task-switching and health was not significant when pain levels were reported to be lower than usual. The results suggest that task-switching ability may be particularly beneficial for managing transient increases in pain.

Previous literature suggests task-switching is an important cognitive function for promoting physical and mental health, and it may facilitate effective coping with acute episodes of pain. For example, pain, even when short-term, is associated with catastrophizing, negative affect, and reduced physical activity (Edwards, Haythornthwaite, Sullivan, & Fillingim, 2004; Hsieh, Tripp, Ji & Sullivan, 2010; Fritz, George, & Delitto, 2001). Task-switching allows people to exert greater control over their thoughts (Mitchell et al., 2007) and in the context

of pain, switching may be necessary for disengaging from ruminative thought patterns and catastrophizing that accompany the pain experience. Although this specific hypothesis has not been explicitly tested, it may be a mechanism by which task-switching protects against declines in health, as negative ruminative thoughts have been shown to predict increased inflammation, increased depression, and reduced immune responses to vaccination in older adults (Segerstrom, Schipper, & Greenberg, 2008; Thomsen et al., 2004). Further supporting that task-switching may help people manage pain, participants experiencing high intensity pain exhibited worse performance on an attention task than participants experiencing low intensity pain because they were less able to switch their focus from the pain to the task at hand (Eccleston, 1995). Additionally, maintaining task-switching ability in older adults may promote better adaptation to increases in pain by allowing older adults to adhere to physical activity, remain active in social activities, and perform a number of other health-enhancing behaviors (e.g., Hall, Fong, Epp, & Eli, 2008).

In the current study, subjective cognitive functioning did not have any association with future health. The literature on the importance of subjective cognitive functioning is mixed regarding the extent to which it influences daily behaviors (see Newson & Kemps, 2006; Ponds et al., 2000). Even though it is moderately correlated with measures of self-rated health ($r = .25$ Ponds et al., 2000), which is in turn associated with health, this may be due to a trait-like tendency to perceive things as worse than they are (Martin & Zimprich, 2003). The data from the current study are consistent with literature showing that perceived cognitive functioning may not have an impact on people's daily behaviors, at least not the adaptive behaviors related to increases in pain. Still, the possibility exists that these null relationships mask important individual differences. Perceived cognitive functioning may have more significant health effects for some people than for others, and future research should explore the potential moderators between subjective cognitive functioning and objective measures of health.

Implications for Treatment

The results have important implications for treatment of pain in community dwelling older adults. Our data suggest that maintaining task-switching ability might be particularly beneficial for those adults who are more likely to experience pain frequently. Although others have emphasized the importance of mental activity in older age generally (Hogan, 2005), this is the first evidence to our knowledge that suggests such activity might be beneficial for protecting against health declines in those prone to experiencing pain. One potential way of maintaining task-switching ability is through the use of specific task-switching exercises. Eight weeks of hour-long training sessions can significantly improve task-switching abilities, and these improvements appear to generalize to other tasks of executive functioning (for a review of cognitive training interventions in older adults, see Lustig, Shah, Seidler, & Reuter-Lorenz, 2010). Multimodal interventions which incorporate cognitive training exercise with social components and lifestyle changes (i.e., cardiovascular training) also appear to successfully improve task-switching and other executive functions, although controversy exists regarding the extent to which these improvement generalize to improvements in daily functioning in the real world (Lustig et al., 2010). Nevertheless, the cognitive training literature is promising, and future research should examine if cognitive

training exercises protect against health declines in older adults experiencing increases in pain.

Our results also suggest that pain management strategies, including proper pain medication dosages, proper monitoring of activity level, and the proper rest recommendations be made explicitly clear for older adults, so that effective pain management could be achieved even among those experiencing lapses in task-switching. Pain management approaches that teach people to accept pain (i.e., mindfulness) instead of trying to switch attention away from it may be particularly beneficial for older adults experiencing reduced task-switching abilities (Geiger et al., 2015).

Limitations

The sample was composed largely of Caucasian participants who reported higher wealth and education relative to the general population. As such, future work should aim to establish whether the relationships described in the study are generalizable to groups with different demographics. The current study treated the interaction of task-switching and pain as predictors and health as an outcome, but alternate models are possible. Pain could be a consequence of poor health, rather than the cause, or a third factor could be responsible for cognitive decline and decreases in health; alternatively, pain could diminish task-switching ability and place a constraint on coping resources. Additionally, the chronic disease severity variable that we used as part of the health composite was based on prescription medications and did not take into account off-label or over-the-counter medication usage. Other measures including sleep, fatigue, and diet have been independently related to pain, cognitive functioning, and disease progression, and their future inclusion will enhance the conceptual framework of how psychological and physiological factors interact to predict health in older adults (Boggero et al., 2013; Koffel et al., 2015; van den Berg-Emons et al., 2007; Watkins et al., 1995; Scarmeas et al., 2009). Future studies should explore whether these variables fully or partially mediate the relationship between task-switching ability and pain on health.

Conclusion

We found that in a longitudinal study of community-dwelling older adults, changes in pain and task-switching ability interacted to predict future health within people. Specifically, higher-than-usual pain in combination with lapses in task-switching ability in previous months predicted declines in health. The relationship between task-switching and health was not significant when pain levels were lower than average. Further, it was found that only objective measures of cognitive functioning (i.e., task-switching) predicted future health; people's subjective reports of their cognitive functioning did not. Public health initiatives and interventions that promote mental activity have the potential to increase objective task-switching performance and decrease pain-related dysfunction, and may improve health as well as quality of life for older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1.**Study Data Accrual**

NOTE: Cumulative data points represent the total number of data points that were available for analysis.

Figure 2.

Depiction of the Interaction between Task-Switching Ability and Pain Predicting Ill Health 6 Months Later

** = $p < .01$ for the interaction term of task-switching ability and pain predicting ill health 6 months later.

Table 1

Null Model Intercepts (i.e., Sample Means) and ICCs for Wave-Level Variables

Variables with Between- and Within-Person Variance	Intercept	ICC
Task-Switching Ability (Trail-Making Test)	−59.97	.40
Pain	43.72	.41
Log IL-6 (pg/mL)	.41	.27
β2μ (μg/mL)	1.72	.71
Subjective Cognitive Functioning	5.12	.60
Chronic Disease Score	6.94	.81
Composite Health Variable *	0	.73

Note. ICC = Intraclass Correlation Coefficient.

* This variable is a composite of z-scored items.

Table 2

Multilevel Model Predicting Composite III Health from the Interaction of Lagged Prior Wave Deviations in Pain and Prior Wave-Level Deviations in Task-Switching Ability

Fixed Effects	Estimate	S.E.	df	t	p <	95% CI
Intercept	1.24	.38	124	6.15	.0001	.84 – 1.56
Sex	–10.64	9.78	124	–1.09	.27	–16.23 – –7.31
Age	3.23	.84	124	3.83	.0002	1.56 – 4.90
BMI	4.45	.99	124	4.48	.0001	2.48 – 6.42
Pain at Prior Wave	.11	.12	663	.97	.33	.11 – .34
TS at Prior Wave	–.15	.06	663	–2.29	.02	–.28 – –.02
TS at Prior Wave X Pain at Prior Wave	–.03	.003	663	–2.72	.007	–.15 – –.008
Random Effects	Variance	S.E.				
Intercept	2547.47		360.78			
TS at Prior Wave (Level 1)	.04		.04			
Residual	1238.98		71.07			
–2LL = 8266.1						
–2LL over model including only a random effect of pain = 2614.9, $p < .001$.						
$\chi^2 (6) = 517.63$						

Note. BMI = body mass index; TS = task-switching; S.E. = standard error.

Table 3

Multilevel Model Predicting a Composite Ill Health Variable from the Interaction of Lagged Prior Wave Deviations in Pain and Prior Wave-Level Deviations in Subjective Cognitive Functioning

Fixed Effects	Estimate	S.E.	df	t	p <	95% CI
Intercept	-2.47	.31	124	6.32	.0001	-1.04 – -3.29
Sex	-9.70	9.59	124	-1.01	.31	-28.69 – 9.28
Age	3.68	.82	124	4.48	.0001	2.06 – 5.31
BMI	4.42	.96	124	4.60	.0001	2.52 – 6.33
Pain at Prior Wave	.02	.11	681	.19	.85	-.21 – .25
TS at Prior Wave	-5.10	3.05	681	-1.67	.09	-11.10 – .90
TS at Prior Wave X Pain at Prior Wave	-.15	.18	681	-.83	.41	-.52 – .21
Random Effects	Variance	S.E.				
Intercept	2771.74		386.10			
TS at Prior Wave (Level 1)	159.22		53.21			
Residual	1280.28		71.58			
-2LL = 8266.1						
-2LL over model including only a random effect of pain = 1475.1, $p < .001$						
$\chi^2 (6) = 550.43$						

Note. BMI = body mass index; TS = task-switching; S.E. = standard error.