HHS Public Access
Author manuscript
Child Health Care. Author manuscript; available in PMC 2019 September 30.

Published in final edited form as:
Child Health Care. 2018 ; 48(1): 18–37. doi:10.1080/02739615.2018.1441028.

Pain, Pain Catastrophizing, and Individual Differences in Executive Function in Adolescence

Tyler Bell, MA, **Jessica H. Mirman, PhD**, **Despina Stavrinos***
Department of Psychology, University of Alabama at Birmingham

Abstract

Many adolescents will experience pain at some point in their development that can lead to poor quality of life. The largest risk factor for pain is tendencies to magnify and ruminate on pain, known as pain catastrophizing. One mechanism of catastrophizing may be difficulties with executive function, or the ability to cognitively control information. The objective of the current study was to determine if adolescent executive function difficulties relate to high catastrophizing and pain. Fifty adolescents completed measures of pain, pain catastrophizing, and executive function. Path models revealed relations among gender, executive function domains, pain catastrophizing domains, and pain. In general, pain catastrophizing was associated with problems with shifting and inhibition. Females reported high catastrophizing and pain, partially explained by executive function difficulty. Executive function difficulty may help clinicians identify adolescents prone to catastrophize painful events. Interventions addressing these difficulties may reduce catastrophizing as well as pain intensity and duration.

Keywords

adolescence; executive function; cognition; pain; pain catastrophizing

---

Up to 80% of adolescents have experienced pain in the last three months (Roth-Isigkeit, Thyen, Stöven, Schwarzenberger, & Schmucker, 2005). For many, pain is temporary, but for 30% of adolescents this pain becomes chronic (lasting over 6 months) and greatly hinders daily function, psychological adjustment, and quality of life (Hunfeld et al., 2001; King et al., 2011; Roth-Isigkeit et al., 2005). Thus, a critical goal for child health professionals is to identify factors producing maladaptive and persistent pain in adolescence (Zeltzer, Tsao, Bursch, & Myers, 2005). During adolescence, emotional-cognitive processes mature and can impact pain perception (Steinberg, 2005), including attention to pain and executive function. Below, we briefly review the impact of catastrophic thinking on adolescent pain across phenotype (acute versus chronic), age, and gender. The role of cognition on pain perception is discussed and how executive difficulty may underlie tendencies to catastrophize pain.

Over the last two decades, one of the best predictors of pain difficulty and chronicity is pain catastrophizing. Catastrophizing is formally defined as a maladaptive coping strategy

*Corresponding author: **Physical address:** 916 Building, 916 19th Street South, Birmingham AL, 35294-2100, dstavrin@uab.edu, **Phone:** 205.934.7861, **Fax:** 205.934.2295.

involving “an exaggerated negative mental set brought to bear during actual or anticipated painful experience” (Sullivan et al., 2001). This coping style involves rumination and magnification of pain along with feelings of helplessness, which have been shown to underlie pain intensity reported by various pain conditions. For example, in cross-sectional studies, higher catastrophizing predicts higher pain intensity in persons with acute (Suren et al., 2014) and chronic pain (Esteve, Ramirez-Maestre, & Lopez-Marinez, 2007). Prospectively, studies also show that a pattern of catastrophic thinking precedes the development of intense pain after painful events such as major surgery (Pavlin, Sullivan, Freund, & Roesen, 2005) and the commencement of chronic pain disorders from acute injury (Buer & Linton, 2002). Thus, catastrophizing appears as an important antecedent for pain difficulty and can be used to identify individuals at risk for pain development (Edwards, 2005).

Studies have also demonstrated the important role of catastrophizing in adolescents’ pain. Supporting the catastrophizing-pain relationship, Lu et al. (2007) found that adolescents who endorsed higher catastrophizing reported higher pain intensities on measures of thermal, pressure, and cold pain. This is also shown among adolescents with physical disability and chronic pain, with higher catastrophizing relating to higher general pain intensity (Engel, Wilson, Tran, Jensen, & Ciol, 2013). Additionally, higher catastrophizing is associated with greater cold-pressor pain in girls without chronic pain, and higher menstrual pain in girls with chronic pain (Payne et al., 2016). Pain catastrophizing has also been shown to be distinct from anxiety, uniquely predicting greater pain, disability, and poorer quality of life in adolescents with chronic pain (Tran et al., 2015). Prospectively, catastrophizing significantly predicted disability in adolescents with chronic pain (Guite, McCue, Sherker, Sherry, & Rose, 2011; Welkom, Hwang, & Guite, 2013). Because catastrophizing can lead to pain and functional difficulties in adolescents, investigating underlying mechanisms of catastrophizing is warranted.

Typical factors that explain adolescent catastrophizing of pain are age and gender. For example, studies report higher pain intensity and catastrophizing in girls compared to boys; girls are also higher on catastrophizing domains of rumination, magnification, and helplessness (Tremblay & Sullivan, 2010). Regarding age, although younger children shown lower pain tolerance (Lu et al., 2007), older adolescents show more chronic pain and have higher catastrophizing (Payne et al., 2016). Thus, higher catastrophizing is related to more pain in adolescents with and without chronic pain, and may be more problematic in older adolescents who are girls.

Another possible factor that may explain tendencies to catastrophize is executive function maturity. Rapidly changing through adolescence, executive function involves higher-order strategies that cognitively control stimuli information and subsequent behavior through inhibition, shifting, and updating (Miyake et al., 2000). Specifically, inhibition involves suppression of prepotent responses (i.e., response inhibition) and selective attention to relevant stimuli while ignoring task-irrelevant stimuli. Shifting involves the ability to switch between mental sets and rules, and updating involves monitoring information in working memory with addition and deletion. Across studies looking at executive function and pain, inhibition is associated with decreased pain sensitivity (Oosterman, Dijkerman, Kessels, &

Scherder, 2010) and better attentional control away from pain (Verhoeven et al., 2011). Whereas, shifting has been related to the development of persistent pain over 6 to 12 months after major surgery (Attal et al., 2014). Working memory has associated with processing of novel pain stimuli (Legrain, Crombez, Verhoeven, & Mouraux, 2011) and is repeatedly found to be impaired across chronic pain phenotypes (Berryman et al., 2013). Executive function therefore seems related to pain processing; however, the role of executive function in catastrophizing is largely unknown. The current study investigated how individual differences in executive function, measured by task performance and self-report ratings, are associated with adolescents' catastrophizing and general pain. Therefore, it expands the literature on cognitive mechanisms of pain processing by advancing our understanding of how top-down cognition impacts catastrophic thinking. Findings have important implications for considering cognitive factors impacting adolescent pain perception, using both clinical and experimental measures of executive difficulty.

Hypotheses

1. Greater executive difficulty would be associated with higher levels of catastrophizing and pain. Specific hypotheses on which domains of catastrophizing will be associated with poorer executive function were not made due to the lack of research in this area.

2. Females would report higher pain intensity and catastrophizing as shown in previous research (Lu et al., 2007). Secondly, we hypothesized that gender differences in catastrophizing were partially explained (significant indirect effect) by difficulties in executive function.

Participants

Fifty adolescents between the ages of 16 to 19 years (M_{age}=17.56, *SD*=1.15) were recruited from a large university in the Southeast through community flyers and through the university's webpage for study opportunities from July 2016 to March 2017. There was a slight majority of females (56%, *n*=28) and Caucasian adolescents (68%, *n*=34), with smaller proportions of African-Americans (26%, *n*=13) and Asians (6%, *n*=3); see Table 2. The study protocol was approved by the university's Institutional Review Board.

Procedure

As part of a larger study on cognition and driving, participants completed cognitive tasks (reviewed in Table 1) and questionnaires regarding catastrophizing and executive function during a single visit to the laboratory. Participants provided informed consent or assent (with parental consent for adolescents younger than 18). Each participant was remunerated with a small monetary incentive for participation.

Materials

Pain catastrophizing

The Pain Catastrophizing Scale (Sullivan, Bishop, & Pivik, 1995) was used to measure amount of catastrophizing. Participants reflected on past painful experiences and rated how often they experienced 13 thoughts and feelings (e.g., *I worry all the time about whether the pain will end*) when in pain, from 0 (not at all) to 4 (all the time). Items were summed to produce a total catastrophizing score (α=.92) and divided into three subscales: rumination (4 items; α=.92), magnification (3 items; α=.73), and helplessness (6 items; α=.86). Greater scores on the Pain Catastrophizing Scale is weakly associated with negative affect (r= .28) and moderately associated with pain interference (r=.39) and intensity (r=.53) (Osman et al., 2000). Sullivan et al. (1995) describes clinical levels of catastrophizing as scores >30, clinical levels of rumination >11, clinical levels of magnification >5, and clinical levels of helplessness >13. Scores higher than these cutoffs indicated individuals scoring over the 75th percentile of persons with chronic pain (Sullivan et al., 1995). These cut-offs were used to determine clinical levels of catastrophizing in the sample, but continuous scores were used for correlation and path analyses.

General pain intensity

We utilized the Visual Analogue Scale (VAS) on the McGill Pain Questionnaire-Short-Form (MPQ-SF) (Melzack, 1987) to determine general pain intensity. The VAS measures pain on a 100mm interval from 0 pain to 100 worst possible pain. Participants marked a line through the spot on the line where they feel their general pain lies. VAS scores provided at the beginning and the end of the study appointment were averaged to produce general pain. The reliability of this composite score was high (α=.97).

Performance measures.—Three cognitive tasks were used to provide performance-based measures of executive function considered to tap the following domains: shifting, inhibition (selective attention and response inhibition), and working memory.

Shifting and selective attention (inhibition)

The second and third subtests of the Useful Field of View (UFOV) (Ball & Owsley, 1993) were used to measure attentional shifting and selective attention, a measure of inhibition. These tests have been validated as measures of attention in pediatric populations, (Bennett, Gordon, & Dutton, 2009) especially adolescents (McManus, Cox, Vance, & Stavrinos, 2015). In addition to visual processing and attention, UFOV captures supervisory control processes (Daigneault et al., 2012; Schmidt et al., 2016) and has been used to measure executive function (Whelihan et al., 2005). Specifically, the second subtest (UFOV-2) measures divided attention, an aspect of shifting (Reitan, 1958), by requiring identification of a central target while also locating a simultaneously presented peripheral target. This subtest moderately correlates with standard measures of shifting like Trail Making Task B (Vance et al., 2006; Vance, Wadley, Crowe, Raper, & Ball, 2011) though less reliant on motor skills. Attentional inhibition was measured using the third subtest (UFOV-3) (Ball & Owsley, 1993). UFOV-3 measured selective attention, requiring participants to complete the same tasks as UFOV-2 but in the presence of distractors displayed across the computer screen. Selective attention, effortful concentration away from distractors, is considered a primary form of inhibitory control alongside response inhibition (Friedman & Miyake, 2004; Houghton & Tipper, 1996) and studies show UFOV-3 predicts inhibitory control in daily activities (i.e., driving; (Wood, Chaparro, Lacherez, & Hickson, 2012). The software provides an exposure threshold at which 75% of responses are correct to measure optimal shifting and selective attention.

Response inhibition

The classic Stroop-Color task (Stroop, 1935) was used to also measure response inhibition. This task was computerized and required participants to complete one trial. The trial involved naming four ink colors for words that matched semantic meaning of words presented (congruent) and ink colors that did not match semantic meanings (incongruent). Participants also indicated the ink color of rectangles (control). For each stimulus presented, participants pressed a letter on the keyboard representing one of four colors as fast as possible. There were 84 trials: four colors showed in three conditions (congruent, incongruent, and control) with seven repetitions each. Response inhibition was measured as the difference between the average reaction time (ms) in incongruent trial minus the mean reaction time during the congruent trials. A natural logarithmic transformation was applied to reduce variance from outlying reaction times similar to prior studies (Carpenter, Schreiber, Church, & McDowell, 2006).

Working memory

The Automated Operational Span Task (A-OSPAN) (Unsworth, Heitz, Schrock, & Engle, 2005) was used to measure working memory capacity. Participants were shown a visual sequence of 3–7 letters that needed to be recalled after an equal number of math problems were completed in between. In the task, participants must have remained ≥85% accurate on math problems to provide valid results. This method helps to maintain proper levels of effort during the task. Working memory capacity was measured as the sum of all perfectly recalled sets (e.g., 5 letters + 7 letters perfectly recalled=12).

Self-reported executive function—In addition to performance-based measures, behavioral ratings of executive function were obtained using the Behavior Rating Inventory of Executive Function (BRIEF) (Roth & Gioia, 2005). Two forms were available depending on the age of the participant: BRIEF-SR (<19 years) and BRIEF-A (19+ years). This BRIEF is considered a valid scale of executive function that captures real-world difficulties (Gioia, 2000) complementing performance measure (Toplak, West, & Stanovich, 2013). To improve ecological validity and reduce negativity bias, this measure avoids direct inquiries about cognitive problems but instead scores executive function by difficulty ratings on everyday behaviors. On both forms, participants rated behavioral manifestations of executive function within the past month using a three-point scale: never (1), sometimes (2), and often (3). Frequency of the behaviors were summed to indicate difficulties in a particular executive function domain. We used domains assessing those that best aligned with a widely-adopted theoretical distinction of executive function (Miyake et al., 2000) including inhibition, working memory, and shifting. Example items for each domain include *"I have problems waiting my turn"* (inhibition), *"I have a short attention span"* (working memory), or *"I have trouble changing from one activity or task to another"* (shifting). Each domain and composite raw scores were converted to gender-and age-normed *T*-scores to reflect individual difficulty compared to a diverse multisite United States based sample (Roth & Gioia, 2005). To combine scores for adolescents 16–18 (BRIEF-SR) and 19 (BRIEF-A), *T*-

scores were used because they provided standardization across forms. On both forms, reliability was acceptable for subscales of inhibition (αs=.73–.83), shifting (αs=.67–.71), and working memory (αs=.83–.84). Additionally, this instrument includes the Negativity Scale which quantifies the extent that respondents answer in an overtly negative manner on selected questions. This scale includes a conservative cutoff for negative bias (>5) that invalidates scores. Owing to the nonclinical nature of the sample, no participants exhibited obvious negativity bias (M=.28, SD=.81; range=0 to 5).

Statistical analyses—Correlations were used to examine associations among inhibition, working memory, and shifting (both performance-based and behavioral rating) with total catastrophizing as well as subscales of rumination, magnification, and helplessness. Next, partial least squares (PLS) structural equation models (Ringle, Wende, & Will, 2005) was used separately for performance and behavior ratings to determine unique predictors of catastrophizing subdomains and general pain to prevent error from multiple testing. Domains of catastrophizing and general pain were regressed on executive function and gender; and domains of executive function were regressed on gender. Unique to PLS, statistical significance is determined using bias-corrected 95% confidence intervals (95%BC CI) from extensive bootstrapping (resamples=5000). A confidence interval without zero shows a significant effect, occurring for 95% of resamples (even after bias correction). Additionally, PLS calculates indirect effects and 95%BC CIs that were used to determine significant mediators between gender and domains of catastrophizing and general pain. Non-parametric bootstrap testing was appropriate as most variables were non-normally distributed (Shapiro-Wilk tests, ps<.05), except for self-reported shifting (p=.492), helplessness (p=.058).

Results

Participant characteristics

Descriptive statistics are listed in Table 2. Overall, 38% of adolescents reported some amount of pain (VAS >4mm, n=19) and there were substantial amounts of catastrophizing reported. Using cutoffs described by Sullivan et al. (1995), 22% (n=11) persons had clinically severe catastrophizing, 34% (n=17) had clinically severe rumination, 30% (n=15) had clinically severe magnification, and 18% (n=9) had clinically severe helplessness.

Gender Differences

First, to determine if there were gender differences on cognitive, PCS, or general pain scales, independent-t tests were conducted. Girls had significantly higher A-OSPAN scores (t(52.75)=2.13, p=.039, d=.62), higher general pain (t(32.42)=2.23, p=.033, d=.78), and greater rumination (t(48)=1.86, p=.07); see Table 2. There were no differences found on the PCS total score (p = .182), or on the subscales of magnification (p=.218) and helplessness (p=.521) or any other cognitive measures (ps>.05) by gender. Secondly, independent sample t-tests showed no differences by race (white versus non-white) on all performance and self-reported executive function, PCS total and subscales, nor amounts of general pain (ps>.10). Lastly, bivariate correlations showed no associations among age and executive function, catastrophizing, or general pain (ps>.05).

Relations between executive function, catastrophizing, and pain

Bivariate correlations between catastrophizing, individual domains of catastrophizing, general pain, and executive functions are shown in Table 2. Underlying assumptions required for path analysis (e.g., no multicollinearity between predictors) were met. Consistent with the literature and associated hypotheses, higher general pain was significantly related to greater catastrophizing, particularly greater feelings of helplessness. Regarding executive function, individuals with greater self-reported shifting difficulties rated higher overall catastrophizing as well as higher amounts of rumination, helplessness, and magnification. Likewise, greater behavior-measured in difficulties working memory were associated with higher overall catastrophizing, rumination, and helplessness, but not magnification. Looking at performance-based executive function, worse selective attention, indexed by higher UFOV-3 scores, was associated with greater magnification of pain and interference was associated with more helplessness. Self-reported difficulties with inhibition and task-measured difficulties in shifting and inhibition were not correlated with global or individual domains of catastrophizing. Greater difficulties with working memory were associated with higher general pain, but no other self-report or task-based executive function measures.

Relations between self-report and performance measures

After controlling for age and gender (adjusted *T*-scores), self-reported difficulties with shifting related to greater interference on Stroop (r=.29, p=.043). However, self-reported difficulties with working memory and inhibition did not significantly relate to scores on UFOV-2, UFOV-3, A-OSPAN, or Stroop (ps>.05). Because of the lack of significant correlations, subsequent path analyses examined associations between self-report or performance-based executive function and catastrophizing domains separately.

Self-reported executive function on catastrophizing

To determine the unique effect of self-reported executive function difficulties and the indirect effects of gender, a path model was conducted with behavioral ratings of executive function and gender as exogenous variables and domains of catastrophizing and general pain as endogenous variables (see Figure 1). After 5,000 resamples, self-reported executive function difficulties related to two catastrophizing subdomains. Specifically, adolescents reporting greater shifting difficulties reported higher amounts of rumination (95%BC CI: .01 to .70). Regarding gender effects, females reported greater difficulties shifting compared to males (95%BC CI: .02 to .47). Looking at indirect effects of gender, there was a marginally significant path such that females reported greater rumination than males indirectly through higher reported executive difficulties (95%BC CI: −.02 to .25). Executive difficulties and gender accounted for 24% of the variability in rumination (95%BC CI: .20 to .65), 14% of the variability in magnification (95%BC CI: .16 to .58), and 19% of the variability in helplessness (95%BC CI: .17 to .62), and 21.0% of variability in general pain (95%BC CI: .31 to .75).

Performance executive function on catastrophizing

After 5,000 resamples there were significant effects between domains of performance-measured executive function and gender on domains of catastrophizing and general pain, as seen in Figure 2. Worse inhibition, indexed by higher interference scores on the Stroop task, were associated with higher helplessness when in pain (95%BC CI: .02 to .43). Secondly, worse inhibition, indexed by greater scores on UFOV-3, were associated with higher magnification of pain (95%BC CI: .04 to .57). Results also indicated that females had better working memory compared to males (95%BC CI: .03 to .53), reported high amounts of rumination (95%BC CI: .001 to .60), and reported higher general pain (95%BC CI: .10 to .50). Regarding mediation, there were no significant indirect effects of gender on rumination, magnification, and helplessness. Task-based executive difficulties and gender accounted for a 12.6% of the variability in rumination (95%BC CI: .08 to .45), 19.0% (95%BC CI: .10 to .42) of the variability in magnification, 14.6% of the variability in helplessness (.04 to .33), and 22.4% of the variability in general pain (95%BC CI: .05 to .29).

Discussion

Partially supporting the main hypothesis, problems in specific executive functions corresponded to higher catastrophizing in adolescents. However, executive function does not contribute to catastrophizing in a unitary manner, as hypothesized, but from disruption in certain strategies. First, self-reported problems with shifting related to greater rumination when in pain. Though research on rumination and cognition is scant in pain literature, this aligns with findings in depressive rumination. Specifically, depressive rumination, negative thoughts about oneself, is associated with difficulties in working memory, but this is driven by the inability to shift mental sets (De Lissnyder, Koster, & De Raedt, 2012). The impaired disengagement theory purports that people with depression ruminate on negative self-referent material, resulting from the inability to attentionally shift problem-solving strategies (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). However, the theory notes that rumination is typically useful as it cues contemplation of possible causes and consequences in response to internal/external stressors, then used to guide self-regulation of emotion and behavior away from stress. For some individuals, rumination becomes problematic because they are unable to disengage from negative self-referent mental sets, removing adaptive value for behavioral control. Similarly, our results may support the application of the impaired disengagement theory to pain catastrophizing in adolescence. In fact, pain catastrophizing is explicitly defined as a “mental set brought to bear” during pain sensation or threat (Sullivan et al., 1995). Relating to development, adolescents unable to switch away from catastrophic thinking may be at risk for chronic pain maintenance and disorder (though this remains to be explored). Alongside shifting, subsequent problems with working memory, trouble removing irrelevant material from the mind and adding relevant material, may explain why some individuals focus on pain longer, as indicated in the bivariate correlations, but this was accounted for by shifting difficulty in the path model. Therefore, pain rumination during adolescence appears driven by problems with attentional disengagement rather than updating of information in active memory.

Adolescents who performed worse on one measure of inhibitory control reported higher magnification when in pain. Worse selective attention reported related to higher pain magnification, complementing literature on attentional biases to pain. Across studies, persons reporting higher pain (Boyer et al., 2005) and higher catastrophizing show poorer selective attention in the face of pain-related distractors (Dehghani, Sharpe, & Nicholas, 2003; Roelofs, Peters, Zeegers, & Vlaeyen, 2002). In addition to problems with disengagement, selective attention away from goal-relevant stimuli to pain processing is thought to underlie initiation and maintenance of chronic pain and is especially relevant in adolescence, a period of rapid cognitive change. However, adolescents' progression from poor selective attention to pain biases is not known, but current findings can guide future investigations. Within this study, individuals with poorer selective attention away from neutral distractors towards goal-relevant stimuli reported greater magnification when in pain. It is possible that for many adolescents who continually attend and amplify pain (or increased threat value), saliency for pain stimuli, attentional bias, may increase overtime, and collectively increase adolescents' susceptibly to persistent pain. Longitudinal and experimental studies are needed to elucidate this pathway and could help detect adolescents with greater catastrophizing who are at risk for pain complications. Indeed, impaired selective attention is a hallmark feature of adults with chronic pain (Grisart & Plaghki, 1999) and may exist in a premorbid form in adolescence where selective attention begins to solidify (McKay, Halperin, Schwartz, & Sharma, 1994). Secondly, higher Stroop interference was associated with greater feelings of helplessness. This finding suggests that during pain evaluation, an individual with poor inhibition may be more overwhelmed with pre-learned pain behavior (anxiety, avoidance, fear) (Asmundson, Noel, Petter, & Parkerson, 2012), reducing the use of adaptive strategies (e.g., confronting) and increasing feelings of uncontrollability (Compas, 1987).

Lastly, gender played a significant role in pain catastrophizing alongside certain executive functions. Supporting our second hypotheses, girls had higher general pain compared to males similar to previous studies (Tremblay & Sullivan, 2010). However, in this non-clinical sample, there were no gender differences on overall catastrophizing. Instead, girls showed higher rumination compared to boys, but no greater magnifying thoughts or helplessness when in pain. This may indicate that higher catastrophizing in girls may be driven by higher rumination. This interpretation is alignment with research showing that, generally, women are slightly more likely to ruminate on negative material than men (Johnson & Whisman, 2013). Interestingly, after accounting for catastrophizing domains, there was no significant effect of gender on general pain and more frequent executive function disruption partially accounted for the effect of gender on rumination. Problems with cognitive control of attention, executive function, related to greater rumination, and because girls rated greater executive difficulties, they showed higher rumination. The relation between gender and general pain was not significant after accounting for executive difficulty and catastrophizing. This supports the mediating role of catastrophic thinking between gender differences in pain (Edwards, Haythornthwaite, Sullivan, & Fillingim, 2004), but adds the important role of high-order thinking. Specifically, higher pain in females may be accounted for by problems switching from mental sets and tasks, which leads to persistent thinking of pain.

A surprising but important finding from our study is that self-reported difficulties in working memory and inhibition did not correspond to decrements on performance-based tasks. This likely reflects differences between “cold” and “hot” executive functions (Zelazo & Carlson, 2012). Measures such as A-OSPAN capture decontextualized cognitive processes without a significant affective component (cold). Whereas, self-reported measures like the BRIEF capture cognitive processes operating in emotionally significant, everyday contexts (hot). In support of a hot distinction, factor analyses show that shifting, but not working memory or inhibition, loads onto the emotional-regulation scale of the BRIEF (Egeland & Fallmyr, 2010). Thus, performance and self-report measures capture distinct but commentary aspects of executive function (isolated and everyday disruptions within affective contexts).

Alternatively, divergence between performance and self-reported executive function could emerge from different test formats. Performance tasks are algorithmic and measure efficiency of higher-order information processing, whereas, self-reported ratings are reflective and examine behavioral control involving personal goals and beliefs (Toplak, West, & Stanovich, 2013). Toplak et al. (2013) theorized that performance tasks capture basic supervisory strategies while the BRIEF (and other surveying/interviewing techniques) captures how well we apply these strategies to regulate real-world actions for personal goal achievement. Moreover, algorithmic tests are considered narrow (but vital) indexes of executive functions while reflective tests are broad indexes. Failure to use both narrow and broad indexes can overlook executive difficulties. Specifically, worse performance on the Stroop or UFOV-3 cannot index all the ways that someone has trouble with inhibitory control but self-report instruments address personally significant problems otherwise missed. Conversely, a lack of difficulties in everyday behavior does not mean participants have typical executive processes per se. As highlighted by this study, disentangling the cognitive mechanisms beneath catastrophizing will require consideration of both cold/algorithmic tests of inhibition and hot/reflective tests of shifting.

Findings should be interpreted in considerations of both limitations and strengths. Primarily, this study was cross-sectional and the results cannot permit us to determine the direction of executive function and catastrophizing relations. While it is more likely that executive difficulties lead to problems with focusing on negative pain material, catastrophic thinking and attentional bias toward pain may precede executive function disruptions. Greater catastrophizing can exacerbate attentional interference (Vancleef & Peters, 2006) which may explain lower cognitive performance shown on performance and self-reported ratings. In addition, conservative bootstrapping techniques were applied to estimate and remove small sample bias; significant effects were present across 95% of the 5000 resamples. In addition, future studies should include parents as studies show that parental responses and catastrophizing can also increase the risk of chronic pain and related disability in adolescents (Caes, Vervoort, Eccleston, Vandenhende, & Goubert, 2011; Logan & Scharff, 2005; Simons, Claar, & Logan, 2008; Wilson, Moss, Palermo, & Fales, 2013). However, adolescent catastrophizing moderates the impact of parental behavior and adolescent pain symptoms (Williams, Blount, & Walker, 2010). As suggested by current findings, executive difficulty may also moderate the negative impact of parental catastrophizing on adolescent catastrophizing and pain.

Lastly, the self-report nature of the BRIEF could make it susceptible to negativity bias, though there are reasons to doubt this as the underlying mechanism for higher catastrophizing. First, only one self-report subscale accounted for catastrophizing domains in our path model, whereas negativity bias supports significance for all self-report scales. Second, all participants did not meet the cutoff for negativity bias on the Negativity Scale. Third, UFOV-3 and Stroop, performance measures, were predictive of catastrophizing. Lastly, shifting difficulties reflected worse Stroop interference, thus relating to non-affective cognitive problems. However, research in chronic pain disorders should control for negative affect due to high psychiatric comorbidity (Bair, Robinson, Katon, & Kroenke, 2003).

Implications for Practice

In conclusion, being able to quickly shift mental sets selectively attend away goal-irrelevant material, and inhibit goal-inappropriate responses may explain individual differences in catastrophic thinking about pain among adolescents. Measures of certain executive functions may help clinicians identify adolescents prone to catastrophic thinking and, therefore, difficulties after painful events. However, our study highlights the need for additional instrument exploration and validation. Promising measures may be ones capture basic inhibitory control (Stroop and UFOV-3) and daily disruption in shifting behavior (BRIEF). Future research should explore other classic instruments (e.g., Test of Everyday Attention, Trail Making Task Part, Wisconsin Cart Sorting Task) and self-report scales (e.g., Dysexecutive Questionnaire) to detect persons with catastrophizing phenotypes at greater risk of pain-related disorders and disability.

Furthermore, interventions modifying catastrophizing may be effective to the extent that they also consider the co-occurring difficulties with executive function. One promising intervention is cognitive-behavioral therapy which has been shown to reduce chronic (Janicke & Finnev, 1999; Schwartz, Radcliffe, & Barakat, 2007; Walco, Sterling, Conte, & Engel, 1999) and acute pain (Powers, 1999). Among adolescents with chronic pain, modifications of CBT such as Acceptance and Commitment Therapy (ACT) can directly reduce catastrophic thinking alongwith anxiety and disability (Gauntlett-Gilbert, Connell, Clinch, & McCracken, 2012). As supported by current findings, such interventions may work by helping adolescents disengage their attention from catastrophizing towards acceptance and positive reframing of pain. Moreover, CBT and standard medical care have been shown to provide the best pain relief in adolescents than either alone (Robins, Smith, Glutting, & Bishop, 2005), supporting multimodal treatment. Using similar interventions, child health professionals may have the ability to improve adolescent pain, possibly by reducing certain executive difficulties and catastrophizing.

Acknowledgements and Funding:

This work was supported by the Alabama Department of Transportation (ALDOT). The opinions, views, or comments expressed in this paper are those of the authors and do not necessarily represent the official positions of funding departments. A special thank you to the UAB Edward R. Roybal Center for Translational Research in Aging and Mobility NIA 2 P30 AG022838, the UAB Department of Psychology, and the Translational Research for Injury Prevention (TRIP) Laboratory.

Acknowledgement: We thank Caitlin Northcutt Pope for consultation regarding instrument selection, administration, and interpretation.

Abbreviations:

A-OSPAN	automated Operation Span task
BRIEF	Behavioral Rating Inventory of Executive Function
MPQ-SF	McGill Pain Questionnaire Short Form
UFOV	Useful Field of View

Reference

Asmundson GJ, Noel M, Petter M, & Parkerson HA (2012). Pediatric fear-avoidance model of chronic pain: foundation, application and future directions. Pain Research Management, 17(6), 397–405. [PubMed: 23248813]

Attal N, Masselin-Dubois A, Martinez V, Jayr C, Albi A, Fermanian J, … Baudic S (2014). Does cognitive functioning predict chronic pain? Results from a prospective surgical cohort. Brain, 137(3), 904–914. [PubMed: 24441173]

Bair MJ, Robinson RL, Katon W, & Kroenke K (2003). Depression and pain comorbidity: A literature review. Archives of Internal Medicine, 163(20), 2433–2445. [PubMed: 14609780]

Ball K, & Owsley C (1993). The Useful Field of View Test: A new technique for evaluating age-related declines in visual function. Journal of the American Optometic Association, 64(1), 71–79.

Bennett DM, Gordon G, & Dutton GN (2009). The Useful Field of View Test: Normative data in children of school age. Optometry & Vision Science, 86(6), 717–721. [PubMed: 19417701]

Berryman C, Stanton TR, Jane Bowering K, Tabor A, McFarlane A, & Lorimer Moseley G (2013). Evidence for working memory deficits in chronic pain: A systematic review and meta-analysis. Pain, 154(8), 1181–1196. [PubMed: 23707355]

Boyer MC, Compas BE, Stanger C, Colletti RB, Konik BS, Morrow SB, & Thomsen AH (2005). Attentional biases to pain and social threat in children with recurrent abdominal pain. Journal of Pediatric Psychology, 31(2), 209–220. [PubMed: 15843503]

Buer N, & Linton SJ (2002). Fear-avoidance beliefs and catastrophizing: occurrence and risk factor in back pain and ADL in the general population. Pain, 99(3), 485–491. [PubMed: 12406524]

Caes L, Vervoort T, Eccleston C, Vandenhende M, & Goubert L (2011). Parental catastrophizing about child's pain and its relationship with activity restriction: the mediating role of parental distress. PAIN®, 152(1), 212–222. [PubMed: 21126822]

Carpenter KM, Schreiber E, Church S, & McDowell D (2006). Drug Stroop performance: relationships with primary substance of use and treatment outcome in a drug-dependent outpatient sample. Addictive Behaviors, 31(1), 174–181. [PubMed: 15913898]

Compas BE (1987). Coping with stress during childhood and adolescence. Psychological Bulletin, 101(3), 393–403. [PubMed: 3602247]

De Lissnyder E, Koster EH, & De Raedt R (2012). Emotional interference in working memory is related to rumination. Cognitive Therapy and Research, 36(4), 348–357.

Dehghani M, Sharpe L, & Nicholas MK (2003). Selective attention to pain-related information in chronic musculoskeletal pain patients. Pain, 105(1–2), 37–46. [PubMed: 14499418]

Edwards RR (2005). Individual differences in endogenous pain modulation as a risk factor for chronic pain. Neurology, 65(3), 437–443. [PubMed: 16087910]

Edwards RR, Haythornthwaite JA, Sullivan MJ, & Fillingim RB (2004). Catastrophizing as a mediator of sex differences in pain: differential effects for daily pain versus laboratory-induced pain. Pain, 111(3), 335–341. [PubMed: 15363877]

Egeland J, & Fallmyr Ø (2010). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function (BRIEF): Support for a distinction between emotional and behavioral regulation. Child Neuropsychology, 16(4), 326–337. [PubMed: 20209415]

Engel JM, Wilson S, Tran ST, Jensen MP, & Ciol MA (2013). Pain catastrophizing in youths with physical disabilities and chronic pain. Journal of Pediatric Psychology, 38(2), 192–201. [PubMed: 23033363]

Esteve R, Ramirez-Maestre C, & Lopez-Marinez AE (2007). Adjustment to chronic pain: the role of pain acceptance, coping strategies, and pain-related cognitions. Annals of Behavioral Medicine, 33(2), 179–188. [PubMed: 17447870]

Friedman NP, & Miyake A (2004). The relations among inhibition and interference control functions: a latent-variable analysis. Journal of Experimental Psychology: General, 133(1), 101–135. [PubMed: 14979754]

Gauntlett-Gilbert J, Connell H, Clinch J, & McCracken LM (2012). Acceptance and values-based treatment of adolescents with chronic pain: Outcomes and their relationship to acceptance. Journal of Pediatric Psychology, 38(1), 72–81. [PubMed: 23071352]

Grisart JM, & Plaghki LH (1999). Impaired selective attention in chronic pain patients. Eur Journal of Pain, 3(4), 325–333.

Guite JW, McCue RL, Sherker JL, Sherry DD, & Rose JB (2011). Relationships among pain, protective parental responses, and disability for adolescents with chronic musculoskeletal pain: the mediating role of pain catastrophizing. Clinical Journal of Pain, 27(9), 775–781. [PubMed: 21593664]

Houghton G, & Tipper SP (1996). Inhibitory mechanisms of neural and cognitive control: Applications to selective attention and sequential action. Brain and Cognition, 30(1), 20–43. [PubMed: 8811979]

Hunfeld JA, Perquin CW, Duivenvoorden HJ, Hazebroek-Kampschreur AA, Passchier J, van Suijlekom-Smit LW, & van der Wouden JC (2001). Chronic pain and its impact on quality of life in adolescents and their families. Journal of Pediatric Psychology, 26(3), 145–153. [PubMed: 11259516]

Janicke DM, & Finnev J (1999). Empirically supported treatments in pediatric psychology: Recurrent abdominal pain. Journal of Pediatric Psychology, 24(2), 115–127. [PubMed: 10361390]

Johnson DP, & Whisman MA (2013). Gender differences in rumination: A meta-analysis. Personality and Individual Differences, 55(4), 367–374. [PubMed: 24089583]

King S, Chambers CT, Huguet A, MacNevin RC, McGrath PJ, Parker L, & MacDonald AJ (2011). The epidemiology of chronic pain in children and adolescents revisited: A systematic review. Pain, 152(12), 2729–2738. [PubMed: 22078064]

Koster EH, De Lissnyder E, Derakshan N, & De Raedt R (2011). Understanding depressive rumination from a cognitive science perspective: the impaired disengagement hypothesis. Clinical Psychological Review, 31(1), 138–145.

Legrain V, Crombez G, Verhoeven K, & Mouraux A (2011). The role of working memory in the attentional control of pain. Pain, 152(2), 453–459. [PubMed: 21238855]

Logan DE, & Scharff L (2005). Relationships between family and parent characteristics and functional abilities in children with recurrent pain syndromes: An investigation of moderating effects on the pathway from pain to disability. Journal of Pediatric Psychology, 30(8), 698–707. [PubMed: 16093517]

Lu Q, Tsao JC, Myers CD, Kim SC, & Zeltzer LK (2007). Coping predictors of children’s laboratory-induced pain tolerance, intensity, and unpleasantness. J Pain, 8(9), 708–717. [PubMed: 17611165]

McKay KE, Halperin JM, Schwartz ST, & Sharma V (1994). Developmental analysis of three aspects of information processing: Sustained attention, selective attention, and response organization. Developmental Neuropsychology, 10(2), 121–132.

McManus B, Cox MK, Vance DE, & Stavrinos D (2015). Predicting motor vehicle collisions in a driving simulator in young adults using the Useful Field of View assessment. Traffic Injury Prevention, 16(8), 818–823. [PubMed: 25794266]

Melzack R (1987). The short-form McGill Pain Questionnaire. Pain, 30(2), 191–197. [PubMed: 3670870]

Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, & Wager TD (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. Cognitive Psychology, 41(1), 49–100. [PubMed: 10945922]

Oosterman JM, Dijkerman HC, Kessels RP, & Scherder EJ (2010). A unique association between cognitive inhibition and pain sensitivity in healthy participants. European Journal of Pain, 14(10), 1046–1050. [PubMed: 20493746]

Osman A, Barrios FX, Gutierrez PM, Kopper BA, Merrifield T, & Grittmann L (2000). The Pain Catastrophizing Scale: Further psychometric evaluation with adult samples. Journal of Behavioral Medicine, 23(4), 351–365. [PubMed: 10984864]

Pavlin DJ, Sullivan MJ, Freund PR, & Roesen K (2005). Catastrophizing: A risk factor for postsurgical pain. Clinical Journal of Pain, 21(1), 83–90. [PubMed: 15599135]

Payne LA, Rapkin AJ, Lung KC, Seidman LC, Zeltzer LK, & Tsao JC (2016). pain catastrophizing predicts menstrual pain ratings in adolescent girls with chronic pain. Pain Medicine, 17(1), 16–24. [PubMed: 26218344]

Powers SW (1999). Empirically supported treatments in pediatric psychology: Procedure-related pain. Journal of Pediatric Psychology, 24(2), 131–145. [PubMed: 10361392]

Reitan RM (1958). Validity of the Trail Making Test as an indicator of organic brain damage. Perceptual and Motor Skills, 8(3), 271–276.

Ringle C, Wende S, & Will A (2005). Smart PLS 2.0 M3, University of Hamburg.

Robins PM, Smith SM, Glutting JJ, & Bishop CT (2005). A randomized controlled trial of a cognitive-behavioral family intervention for pediatric recurrent abdominal pain. Journal of Pediatric Psychology, 30(5), 397–408. [PubMed: 15944167]

Roelofs J, Peters ML, Zeegers M, & Vlaeyen JW (2002). The modified Stroop paradigm as a measure of selective attention towards painrelated stimuli among chronic pain patients: A meta-analysis. European Journal of Pain, 6(4), 273–281. [PubMed: 12161093]

Roth-Isigkeit A, Thyen U, Stöven H, Schwarzenberger J, & Schmucker P (2005). Pain among children and adolescents: Restrictions in daily living and triggering factors. Pediatrics, 115(2), e152–e162. [PubMed: 15687423]

Roth RM, & Gioia GA (2005). Behavior Rating Inventory of Executive Function-Adult Version. Lutz, FL: Psychological Assessment Resources.

Schwartz LA, Radcliffe J, & Barakat LP (2007). The development of a culturally sensitive pediatric pain management intervention for African American adolescents with sickle cell disease. Children’s Healthcare, 36(3), 267–283.

Simons LE, Claar RL, & Logan DL (2008). Chronic pain in adolescence: parental responses, adolescent coping, and their impact on adolescent’s pain behaviors. Journal of Pediatric Psychology, 33(8), 894–904. [PubMed: 18375447]

Steinberg L (2005). Cognitive and affective development in adolescence. Trends in Cognitive Sciences, 9(2), 69–74. [PubMed: 15668099]

Stroop JR (1935). Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 18(6), 643.

Sullivan MJ, Bishop SR, & Pivik J (1995). The Pain Catastrophizing Scale: Development and validation. Psychological Assessment, 7(4), 524–532.

Sullivan MJ, Thorn B, Haythornthwaite JA, Keefe F, Martin M, Bradley LA, & Lefebvre JC (2001). Theoretical perspectives on the relation between catastrophizing and pain. The Clinical Journal of Pain, 17(1), 52–64. [PubMed: 11289089]

Suren M, Kaya Z, Gokbakan M, Okan I, Arici S, Karaman S, … Dogru S (2014). The role of pain catastrophizing score in the prediction of venipuncture pain severity. Pain Practice, 14(3), 245–251. [PubMed: 23586760]

Toplak ME, West RF, & Stanovich KE (2013). Practitioner Review: Do performance~ based measures and ratings of executive function assess the same construct? Journal of Child Psychology and Psychiatry, 54(2), 131–143. [PubMed: 23057693]

Tran ST, Jastrowski Mano KE, Hainsworth KR, Medrano GR, Anderson Khan K, Weisman SJ, & Davies WH (2015). Distinct influences of anxiety and pain catastrophizing on functional outcomes in children and adolescents with chronic pain. Journal of Pediatric Psychology, 40(8), 744–755. [PubMed: 25840447]

Tremblay I, & Sullivan MJ (2010). Attachment and pain outcomes in adolescents: The mediating role of pain catastrophizing and anxiety. Journal of Pain, 11(2), 160–171. [PubMed: 19853522]

Unsworth N, Heitz RP, Schrock JC, & Engle RW (2005). An automated version of the Operation Span task. Behavioral Research Methods, 37(3), 498–505.

Vance DE, Ball KK, Roenker DL, Wadley VG, Edwards JD, & Cissell GM (2006). Predictors of falling in older Maryland drivers: A structural-equation model. Journal of Aging and Physical Activity, 14(3), 254–269. [PubMed: 17090804]

Vance DE, Wadley VG, Crowe MG, Raper JL, & Ball KK (2011). Cognitive and everyday functioning in older and younger adults with and without HIV. Clinical Gerontologist, 34(5), 413–426. [PubMed: 22563140]

Vancleef LM, & Peters ML (2006). Pain catastrophizing, but not injury/illness sensitivity or anxiety sensitivity, enhances attentional interference by pain. Journal of Pain, 7(1), 23–30. [PubMed: 16414550]

Verhoeven K, Van Damme S, Eccleston C, Van Ryckeghem DM, Legrain V, & Crombez G (2011). Distraction from pain and executive functioning: An experimental investigation of the role of inhibition, task switching and working memory. European Journal of Pain, 15(8), 866–873. [PubMed: 21397536]

Walco GA, Sterling CM, Conte PM, & Engel RG (1999). Empirically supported treatments in pediatric psychology: Disease-related pain. Journal of Pediatric Psychology, 24(2), 155–167. [PubMed: 10361396]

Welkom JS, Hwang W-T, & Guite JW (2013). Adolescent pain catastrophizing mediates the relationship between protective parental responses to pain and disability over time. Journal of Pediatric Psychology, 38(5), 541–550. [PubMed: 23471361]

Williams SE, Blount RL, & Walker LS (2010). Children's pain threat appraisal and catastrophizing moderate the impact of parent verbal behavior on children's symptom complaints. Journal of Pediatric Psychology, 36(1), 55–63. [PubMed: 20484330]

Wilson AC, Moss A, Palermo TM, & Fales JL (2013). Parent pain and catastrophizing are associated with pain, somatic symptoms, and pain-related disability among early adolescents. Journal of Pediatric Psychology, 39(4), 418–426. [PubMed: 24369365]

Wood JM, Chaparro A, Lacherez P, & Hickson L (2012). Useful Field of View predicts driving in the presence of distracters. Optometry and Vision Science, 89(4), 373–381. [PubMed: 22366710]

Zelazo PD, & Carlson SM (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. Child Development Perspectives, 6(4), 354–360.

Zeltzer LK, Tsao JC, Bursch B, & Myers CD (2005). Introduction to the special issue on pain: From pain to pain-associated disability syndrome. Journal of Pediatric Psychology, 31(7), 661–666.

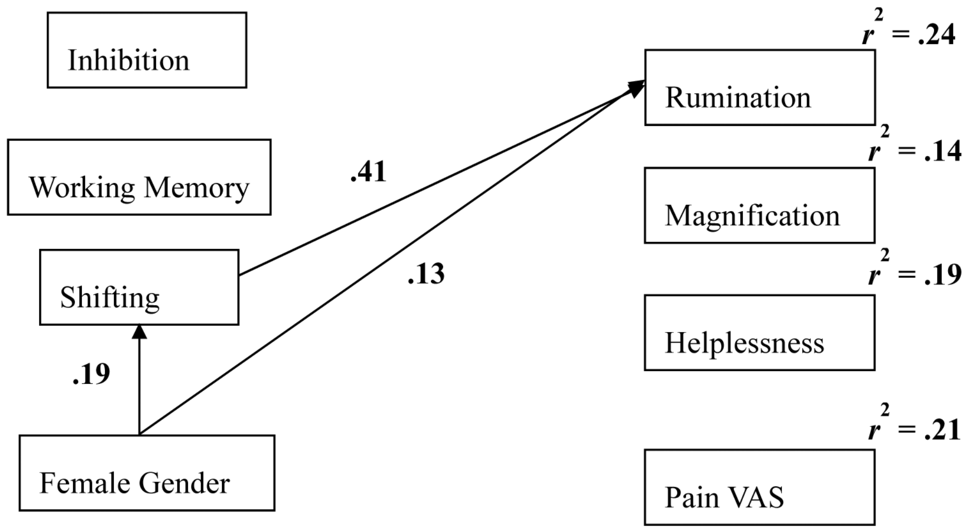

Figure 1.
Self-report EF measures on domains of PC and pain (n = 50). Only significant paths and coefficients shown (no zero in 95%BC CI).

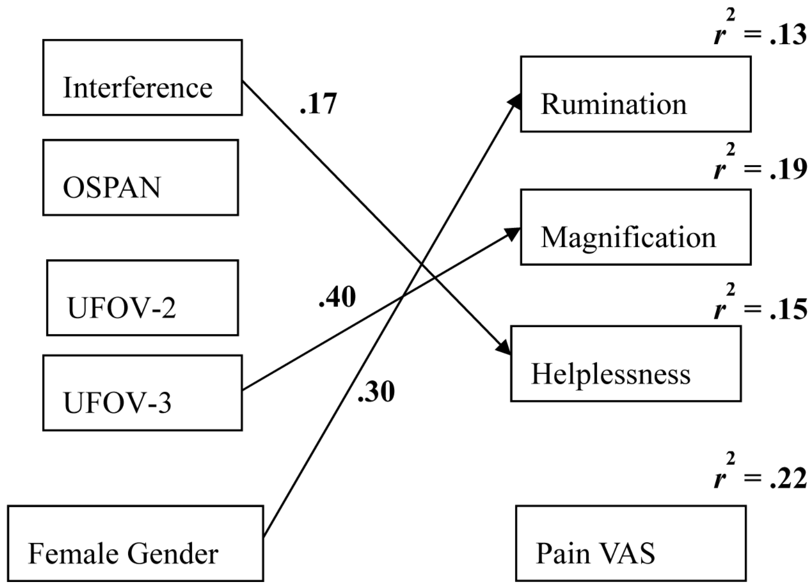

Figure 2.
Performance-based EF measures on domains of PC and pain. Only significant paths and coefficients shown (no zero in 95%BC CI).

Table 1.

Cognitive measures.

Construct	Assessment	Modality	Scoring and Interpretation
Shifting	BRIEF-Shifting	Behavioral Rating	Participants rate how frequent they having difficulties moving from one task to another, tolerate change, and alternate attentional focus. Frequencies are summed with higher values indicating more shifting difficulties.
Shifting	UFOV-2®	Performance Task	During several trials, participant must identify a central target while also locating peripheral target on the screen. Score is calculated in milliseconds at which stimuli was presented for 75% accuracy of identifying central stimuli and locating peripheral stimuli.
Inhibition	BRIEF-Inhibition	Behavioral Ratings	Participants rate how frequently they have difficulty controlling impulses and terminate inappropriate/irrelevant behavior. Frequencies are summed with higher values indicating more inhibition difficulties.
Inhibition	UFOV-3®	Performance Task	During several trials, participant must identify a central and peripheral stimulus target while inhibiting distractor stimuli on the screen. Score is calculated in milliseconds at which stimulus was presented for 75% accuracy of the central stimulus. Higher scores indicate worse inhibition.
Inhibition	Stroop Color-Word Task	Performance Task	Participants must name color of the ink of several presented words. For a portion of trials, the ink color matched the word meaning (congruent) while for other the ink color does not match the word meaning (incongruent). The mean reaction time (milliseconds) of congruent trials are subtracted the mean reaction time of incongruent trials to calculate response inhibition. Higher milliseconds indicates poorer response inhibition (more time needed to inhibit during incongruent condition).
Working Memory	BRIEF-Working Memory	Behavioral Ratings	Participants rate how frequently they have difficulties encoding information, remember information, and transform information to generate/implement plans sequentially. Frequencies are summed with higher values indicating more shifting difficulties.
Working Memory	A-OSPAN	Performance Task	Through several trials, participants must remember letters presented in between math problems which are being solved, and then recalled. Scores are taken from highest number of letters correctly, with higher values indicating greater WM capacity.

Notes. BRIEF=Behavioral Rating Index of Executive Function, A-OSPAN=Automated Operational Span, UFOV=Useful Field of View.

Table 2.

Descriptive information and bivariate correlations.

	Descriptive				Bivariate Correlations				
Variable	***M/n***	***SD/%***	**Min**	**Max**	**PC tot**	**Rum**	**Mag**	**Help**	**GPI**
Male	22	44.00	-	-					
Female	28	56.00	-	-					
White	34	68.00	-	-					
AA	13	26.00	-	-					
Other	3.00	6.00	-	-					
Age	17.56	1.16	16.00	19.00					
PCS total	19.52	11.98	0.00	47.00					
Rumination	7.94	4.83	0.00	16.00	**.90****				
Magnification	3.82	2.99	0.00	11.00	**.80****	**.57****			
Helplessness	7.76	5.58	0.00	23.00	.94**	**.76****	**.69****		
GPI	8.47	15.67	0.00	73.50	.28*	.25	.16	**.30***	
Inhibit.	48.89	9.66	34.00	76.00	.14	.08	.09	.19	.17
WM	53.92	10.82	34.00	75.00	**.32***	**.31***	.17	**.33***	**.33***
Shifting	52.84	9.30	35.00	77.00	**.46****	**.46****	**.35***	**.42****	**.30***
UFOV-2	20.32	9.24	16.70	60.00	−.19	−.16	−.15	−.18	−.01
UFOV-3	67.21	37.47	16.70	176.60	.08	−.10	**.32***	.09	−.05
OSPAN	34.31	17.01	3.00	65.00	−.04	.03	−.04	−.10	.17
Stroop Inter.[a]	124.04	138.21	149.32	606.24	.27†	.25†	.15†	**.28***	.27†

Note. AA = African American, A-OSPAN = Automated Operation Span task, PCS = Pain Catastrophizing Scale, GPI = General Pain Intensity, Inhibit. = Inhibition scale of the Behavioral Rating Inventory of Executive Function, Inter = interference score from the Stroop task, WM = Working Memory scale of the Behavioral Rating Inventory of Executive Function, UFOV = Useful Field of View.

* $p < .10$

† $p < .10$

[a] Natural logarithmic transformation applied