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Pain is Associated with Prospective Memory Dysfunction in Multiple Sclerosis

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Abstract

Prospective memory (PM) pertains to the execution of a future goal or behavior. Initial research implies that people with multiple sclerosis (MS) are apt to show impaired prospective memory for activities of daily living (Rendell, Jensen, & Henry, 2007; Rendell et al., 2012). Yet, PM impairment does not occur in all people with MS. Thus, some other variable besides disease status alone may contribute to PM dysfunction in people with MS. Chronic pain may be such a variable. Approximately 50-70% of people with MS experience significant pain, and such pain has been thought to diminish memory function (Moore, Keogh, and Eccleston, 2009). To investigate this possibility, 96 patients with MS and 29 healthy subjects were administered the Memory for Intentions Screening Test (MIST) (Raskin, Buckheit, & Sherrod, 2010), a well-validated measure of prospective memory, and the Medical Outcomes Study Pain Effects Scale (PES) (Fischer, Rudick, Cutter, & Reingold, 1999) to assess chronic pain. After controlling for demographic variables and disability severity, subjective pain accounted for significant variance in PM, particularly for time-based intentions over sustained delay periods. These data accord well with assertions that pain may degrade ability to remember new intentions, and suggests that pain is associated with PM dysfunction in people with MS.

Multiple sclerosis (MS) ranks among the most prevalent neurological diseases, and it afflicts approximately 30 per 100,000 population globally, although this rate varies widely by region (Milo & Kahana, 2010). The symptoms of MS tend to vary from person to person (Gordon, Lewis, & Wong, 1994), and include deficits in movement, coordination, balance, sensation, speech, and neuropsychiatric disturbance. With regard to the latter, episodic

memory impairment is among the most common neuropsychological problems (Rao, Grafman, & DiGuilio, 1993). Although somewhat controversial, most data suggest that poor memory is due to impaired acquisition of new information (Chiaravalloti & DeLuca, 2008; DeLuca, Barbieri-Berger, & Johnson, 1994; DeLuca, Gaudino, Diamond, Christodoulou, & Engel, 1998). When MS-related memory deficits are present, the degree of impairment can vary from mild to severe (Brassington & Marsh, 1998) and may significantly impact quality of life, occupational and social role fulfillment, and daily living activities such as automobile driving (Bobholz, Gleason, & Miller, 2008).

Although multiple aspects of retrospective memory dysfunction (i.e., recall of events from the recent past) have been examined in people with MS, investigators and clinicians have largely neglected to address prospective memory (PM). PM is arguably a more ecologically relevant aspect of cognition, and it involves the ability to “remember to remember” (McDaniel & Einstein, 2011). Loftus (1971) initially described the construct as a component of episodic memory that pertains to the execution of a future goal or behavior. Subsequent descriptions of PM have outlined its core components, which involve the initial encoding of the intention (i.e., what is to be done and when), retention of the cue-intention pairing over time while engaged in other tasks, automatic and/or strategic monitoring of the environment for the cue, and finally, retrieval and execution of the intended goal (e.g., Kliegel, Jäger, & Phillips, 2008). Practical and conceptual distinctions have been made between time-based and event-based PM cues. Specifically, time-based PM pertains to someone performing a behavior at a particular time (e.g., taking daily medication), whereas event-based memory involves someone performing a behavior in response to a particular cue (e.g., making a doctor appointment if feeling ill) (Henry, MacLeod, Phillips, & Crawford, 2004). According to multiprocess theory, time-based PM generally places greater demands on strategic monitoring and cue detection processes, and is more sensitive to executive dysfunction (e.g., planning and cognitive flexibility) commonly associated with pre-frontostriatal injury (e.g., Raskin, Buckheit, & Waxman, 2012). In contrast, although the cognitive resource demands of event-based PM paradigms can vary widely, as compared to time-based PM they tend to be relatively more automatic/spontaneous and more strongly associated with retrospective learning and memory functions linked to temporolimbic systems. The strategic demands of time- versus event-cued PM may be exacerbated under conditions of long delay (McDaniel, Robinson-Riegler, & Einstein, 1998), which may be particularly sensitive to conditions involving frontal systems (Morgan et al., 2012).

Few studies have examined PM in people with MS. Some have focused upon subjective complaints of forgetfulness (cf. Demers et al., 2011; Pardini et al., 2014). Similar to retrospective memory, people with MS are inclined to report poor PM functioning. Other investigators have assessed PM using objective measures of performance (Bravin, Kinsella, Ong, & Vowels, 2000; Rendell, Jensen, & Henry, 2007; Rendell et al., 2012; Thelen, Lynch, Bruce, Hancock, & Bruce 2014). For example, Bravin et al. (2000) found that people with MS displayed poor performance on one of two PM tests and all indices of the Rey Auditory Verbal Learning Test. Moreover, retrospective memory correlated meaningfully with performance on the PM measures, implying that the two constructs may be indistinct from one another. In contrast, Rendell et al. (2007) found that people with MS with intact retrospective memory recalled fewer future actions than a comparison group. This finding

was consistent with the case study reported by West, McNerney, and Krauss (2007) in suggesting that PM deficits may be independent of retrospective memory problems in MS. In a follow-up study, Rendell et al. (2012) again found that patients with MS demonstrated worse recall of prospective actions than healthy adults; however, when the authors assessed recognition memory for the intentions, the group with MS performed as well as the healthy comparison group. Thus, the MS group seemed to learn intended actions as well as the healthy group, but had greater difficulty recalling them from memory. Presumably, this reflects a process of poor monitoring and cue detection for time- and event-based actions (Raskin, et al., 2012). Furthermore, Kardiasmenos, Clawson, Wilken, and Wallin (2008) evaluated PM for a variety of everyday activities. Some of the intentions were paired with cues which possessed relatively obvious associations (“When you see a picture of your mom, write a letter to your dad.”). Other intentions were cued by more obtuse associations (“When you buy more paint, buy more pens.”), which presumably required more strategic encoding and cue monitoring than the former (McDaniel, et al., 1998). Compared to a healthy comparison group, patients with MS demonstrated worse PM for the activities that were cued by obtuse than obvious associations. Such a finding implies that MS-associated PM deficits are exacerbated when increasing demands are placed upon the individual to generate associative cues for the memories (cf. McDaniel & Einstein, 2011).

Although PM is prone to being diminished in groups of persons with MS, only some individuals show this difficulty. For instance, in the studies by Rendell and colleagues, mean differences between people with MS and the control group on the Virtual Week task were relatively small, as were the effect sizes of these differences. Thus, individual differences between patients may contribute to such dysfunction. One such variable might be pain. Chronic pain occurs commonly in people with MS, and 50-70% of patients present with pain sufficiently severe to merit medical attention (Baši Kes et al., 2009; Solaro et al., 2004). The most common forms of pain in MS are extremity pain (25%), low back pain (30%), painful leg spasm (20%), and headache (25%) (Baši Kes et al., 2009). A considerable literature shows that pain exerts a deleterious effect upon cognitive functioning (Epker & Ogden, 2013). Research has estimated that 41% to 60% of chronic pain patients report cognitive impairment (Jaminson, Sbrocco, & Parris, 1989; McCracken, & Iverson, 2001; Roth, Geisser, Theisen-Goodvich, & Dixon, 2005). However, this is not merely limited to chronic pain, as similar findings are reported in individuals with medical illnesses that involve pain, such as fibromyalgia, migraine, and systemic lupus erythematosus (Denburg, Stewart, Hart, & Denburg, 2003; Grace, Nielson, Hopking, & Berg, 1999; Suhr, 2003). Among these complaints, memory is one of the most common and consistent (Epker & Ogden, 2013). Other factors, such as pain intensity and pain duration, have been shown to be positively correlated with objective measures of retrospective memory impairment in patients complaining of chronic orthopedic pain (Jongsma et al., 2011; Kreitler & Niv, 2007). However, severity of pain-related impairment is questionable. Suhr (2003) found small effect sizes ($r^2_p = .01$ to $.05$) for the impact of pain on measures of retrospective memory in chronic pain patients, suggesting that differences between individuals with and without pain may be modest. Yet, few studies have investigated the effects of pain on cognition in people with MS.

The mechanism by which pain affects memory is uncertain, but some have proposed that its influence is primarily due to its demand upon cognitive resources (e.g., attention). In this view, pain draws attention away from cognitive activities (Moore, Keogh, & Eccleston, 2009), which therefore reduces performance on those activities, particularly among individuals with limited cognitive resources. Consistent with this perspective, pain (even mild physical pain) can negatively impact higher-order cognitive processing, and the acquisition of information for later recall (Sanchez, 2011). Apart from its demands upon cognitive resources, other research implies that pain directly impacts brain structures that subserve memory. Using structural imaging, Sutherland (2012) showed that individuals with chronic back pain had smaller hippocampi compared to healthy controls. McDaniel and Einstein (2011) assert that the medial temporal lobe is involved in some aspects of PM, especially event-based PM. As such, pain may influence PM through distraction and its effect upon neural function.

Based on these considerations, the current study examined the relationship between self-reported pain and prospective memory in people with MS. We anticipated that higher levels of self-reported pain would correspond with worse PM dysfunction in people with MS. Because temporally-based PM presumably places greater demands upon strategic cognitive processes than event-based PM, we anticipated that pain would correlate more saliently with the former rather than with the latter cognitive functions. Among individuals with MS, pain is often comorbid with depression (Benson & Kerr, 2014). Further, a convincing literature reveals that depression coincides with a wide variety of deficits in psychiatric samples, especially involving executive function (cf. Basso, Miller, Estevis, & Combs, 2012; McDermott & Ebmeier, 2009). Among people with MS, depression likewise corresponds with salient deficits involving executive function (Feinstein, 2006). Because prospective memory presumably relies on executive function and strategic processes, the current study further examined the influence of depression on prospective memory performance.

Method

Participants

Participants were recruited from support groups and advertisements in the local National Multiple Sclerosis Society Newsletter. A board certified neurologist made diagnoses in accordance with the revised McDonald et al. (2005) criteria (Polman et al., 2005). Patients were excluded if they had a psychiatric disorder that preceded onset of MS, current or past substance use disorder, history of learning or developmental disorders, or any neurological disease or injury besides MS. All control participants were subject to the same exclusion criteria. All participants signed an informed consent form that described the purpose of the study and their rights as research participants. The study was approved by the local Institutional Review Board.

Participants included 96 individuals with a diagnosis of MS and 29 healthy controls from the community. Descriptive statistics appear in Table 1. Independent samples t-tests and chi-square analyses were conducted to determine if the two groups significantly differed on any of the demographic variables. No significant differences emerged between the groups on education ($t = 0.87, p > .05$), sex ($X^2(1) = 1.89, p > .05$), or self-reported ethnicity ($X^2(5) =$

8.10, $p > .05$). The participants with MS were 5 years older ($t = -2.86$, $p < .01$) than the healthy comparison group.

Materials and Procedures

Participants were administered the research version of the Memory for Intentions Test (MIST; Woods et al., 2008), a measure of prospective memory. Raskin (2004) developed the MIST to be a standardized, psychometrically-sound measure of PM. It requires a delayed execution of intended actions. Specifically, participants are asked to perform eight different PM intentions over a 30-minute period while completing an ongoing task (i.e., word-search puzzle). The PM tasks are systematically varied and balanced in terms of the delay interval (i.e., 2-minute or 15-minute), cue (i.e., time-based or event-based), and response required (i.e., verbal or physical). The research version of the MIST shows strong evidence of reliability (e.g., Woods et al., 2008) and construct validity (e.g., Gupta, Woods, Weber, Dawson, Grant, & The HNRC Group, 2010).

To assess self-reported pain severity, all participants completed the Medical Outcomes Study Pain Effects Scale (PES), which is part of the Multiple Sclerosis Quality of Life Inventory (MSQLI) (Fischer, Rudick, Cutter, & Reingold, 1999). The PES provides an assessment of pain severity and its impact on life activities. Items ask the individual to rate the extent to which pain interferes with mood, ability to walk or move, sleep, work, recreation, and enjoyment of life. As shown in Table 2, the MS patients self-reported experiencing significantly higher levels of pain ($t = -4.90$, $p < .001$). To assess disability severity, all participants completed the timed 25-foot walk. Participants were timed as they walked 25 feet as quickly as possible. As depicted in Table 2, the MS group completed the 25-foot walk more slowly than the healthy comparison group ($t = -3.61$, $p < .001$).

To assess symptoms of depression the Chicago Multiscale Depression Inventory (CMDI) was administered to all participants. The CMDI is a self-report measure of depression that includes mood, evaluative, and vegetative subscales. Research has shown this scale to be a valid and reliable measure of emotional distress among people with MS (Nyenhuis et al., 1998). MS patients self-reported significantly higher levels of depressive symptoms on the mood ($t = -3.80$, $p < .001$), evaluative ($t = -3.20$, $p < .01$), and vegetative ($t = -4.90$, $p < .001$) symptom scales. Notably, however, the T-scores imply that the MS group reported non-clinical levels of emotional distress, as average scores were in the 50's on the mood and evaluative scales (see Table 2). Nonetheless, the MS group reported clinically-significant fatigue, malaise, and discomfort, as reflected by a T-score of 65 on the vegetative symptoms scale. This is an expected difference between the groups, and is likely an epiphenomenon of being symptomatic with MS (Chang et al., 2003). All group statistics are reported in Table 2.

All instruments were administered in accordance with respective standardization instructions. The testing sessions occurred within a quiet laboratory space. To ensure accuracy, all data were entered twice, and discrepancies were identified and eliminated.

Results

Comparison of MS and Control Groups on the MIST

To evaluate and describe the performance of the MS and control groups on the MIST, independent samples t-tests was used. To control for Type I error, a modified Bonferroni correction was employed; only values that accounted for variance at a $p < .01$ level of significance were considered significant.

Descriptive data concerning performance of the healthy comparison group and individuals with MS appear in Table 3. We analyzed whether the two groups differed in MIST performance using a oneway analysis of covariance (ANCOVA). Age was entered as a covariate because the groups differed in age. Analyses revealed that the patients performed significantly worse on the MIST 15-Minute Time-Based Memory index ($p < .01$). As shown in Table 3, the MS group had poorer performance. Age emerged as a significant covariate only for MIST Time-Based Memory ($p < .01$).

Effects of Pain and Depression on the MIST

To evaluate the unique relationship between pain and PM, multiple regression was used. The MIST total score and subtest scores served as the dependent variables in separate regression equations. Independent variables were forcibly entered simultaneously. To control for possible demographic biases, age, education, and sex were entered into the equations. To control for severity of disease-related disability, scores on the timed 25-foot walk were entered. To control for depression severity, the CMDI mood symptom scale was entered. The vegetative subscale was designed specifically to assess physical symptoms of fatigue, pain, and malaise that are commonly endorsed by people with MS (Chang et al., 2003; Nyenhuis et al., 1998). Thus, this scale would likely overlap, and be confounded, with the PES. Further, because the evaluative symptom scale is related to depressed mood, it was not entered into the model, as it would have contributed to untenable multicollinearity in the analyses. To assess the impact of subjective pain, PES total score was entered. To evaluate whether multi-collinearity may have biased the results, tolerances of the independent variables were inspected. Tolerances ranged from 0.77 to 0.99, indicating that multicollinearity was negligible. To identify outliers, Mahalanobis Distance was examined, and an outlier was identified with a value of 25.0. Nonetheless, this was not an influential datapoint, because none of the Cook's Distance or Centered Leverage Values exceeded cutoffs (maximum values were .13 and .21, respectively).

MIST Total Raw Score—Regarding total score on the MIST, total variance accounted for by the predictors approximated 19% (overall $R^2 = 0.19$). Only PES scores accounted for significant variance on the MIST total score ($p < .001$), and it achieved a semi-partial correlation of $r = -0.31$. See Table 4.

MIST 2-Minute Memory (Time-Based and Event-Based)—Regarding Time-Based and Event-Based memories, no predictor accounted for significant variance.

MIST 15-Minute Memory (Time-Based and Event-Based)—With respect to Time-Based Memory, the predictors accounted for 18% of the variance in performance, and only PES scores accounted for a significant proportion of variance (semi-partial correlation = -0.33 , $p = .001$). As shown in Table 4, no variable accounted for significant variance in Event-Based Memory.

MIST Time-Based and Event-Based Composite Scores—MIST scores on the 2- and 15-Minute Time-Based Memory items are summed to form a composite Time-Based Memory score. Likewise, scores on the 2- and 15-Minute Event-Based items are compiled to form a composite Event-Based Memory score. No variable accounted for significant variance on the Event-Based Memory item. In contrast, the PES scores emerged as a significant predictor of the Time-Based Memory item. As shown in Table 4, increasing subjective pain (semi-partial correlation = -0.29 , $p < .01$) correlated with worsening Time-Based Memory on the MIST. The combined model accounted for 17% of the variance on Time-Based Memory.

MIST Action Response Total—The predictors accounted for 14% of the variance on MIST items that required the participants to offer a behavioral response. Only PES scores emerged as a significant predictor. Table 4 shows that increasing pain correlated with worse MIST performance (semi-partial correlation = -0.28 , $p < .01$).

MIST Verbal Response Total—For the MIST items requiring a verbal response, the predictors accounted for 15% of the variance (overall $R^2 = 0.15$). Only the PES achieved a significant relationship (semi-partial correlation = -0.23 , $p < .01$); increasing pain correlated with worse PM.

MIST Recognition Score—None of the predictors accounted for significant variance on the MIST Recognition Score. Notably, age, education, sex, 25-foot walk, and depression severity failed to emerge as significant predictors in any of the models. Regression statistics are reported in Table 4.

Discussion

Consistent with previous work (Rendell et al., 2007; Rendell et al., 2012), the current study revealed that individuals with MS demonstrate diminished prospective memory compared to a control group. Specifically, patients with MS displayed significantly lower scores than the healthy control group on the MIST Total Score, 15-Minute Time-Based Memory, Composite Time-Based Memory, and memories requiring a Verbal Response. These data extend Rendell et al.'s work (2007; 2012), because they show that people with MS demonstrating worse performance on a separate measure of PM. As such, the current study extends the external validity of the initial findings.

As a further contribution to the literature, self-reported pain significantly coincided with memory performance. Specifically, as pain severity increased, prospective memory decreased, especially on the MIST Total Score, 15-Minute Time-Based Memory, Composite Time-Based Memory, Verbal Response, and Action Response scores. Semi-partial

correlations indicated that these relationships were typically moderate, revealing that a considerable proportion of variance on the MIST indices was accounted for by pain severity. Pain emerged as the most salient correlate of memory impairment. Additionally, these significant relationships emerged despite having controlled for potential confounds such as age, depressed mood, sex, education, and the severity of motoric disability.

Furthermore, we hypothesized that performance on the Time-Based MIST measures would be more highly correlated with pain than would the Event-Based indices. Indeed, McDaniel and Einstein (2011) distinguish between time-based and event-based PM. Time-based PM involves recall of an action that must be performed at a specified time. With recall of event-based prospective responses, the person must remember to perform an action when a specified event occurs. Time-based PM requires intrinsic and persistent monitoring of a situation; the person must remember to track the passage of time and also remember to perform a specified action at a designated time. Event-based PM reliably requires fewer strategic resources because such cues are invariably more salient than time-cued PM. They must attend to the event when it occurs, and this event serves to cue the prospective memory. Accordingly, the multi-process model asserts that it is harder to remember time-based actions than event-based responses. Additionally, longer delays from encoding the action to performing it will decrease recall of a prospective response. Accordingly, recall of time-based prospective actions, especially over longer time periods, is more vulnerable to adverse effects of pathological conditions than memory for event-based future actions.

Consistent with these hypotheses, several studies show that Time-Based scores on the MIST are lower than Event-Based scores in people infected with HIV. This adverse effect is more evident on the 15-Minute index than on the 2-Minute score (Morgan et al., 2012; Poquette et al., 2013). The current data reveal a similar pattern of relative performance in people with MS. Compared to a healthy control group, the MS group performed more poorly on the 15-minute Time-Based scale from the MIST, and they also performed worse on the composite Time-Based Memory index. The MS and control groups were indistinguishable on the 2-Minute Memory Indices and on the 15-Minute Event-Based scale. Moreover, subjective pain predicted Time-Based MIST performance, especially on the 15-Minute Time-Based Memory scale. No variable predicted Event-Based Memory. Collectively, the current data accord well with the Multi-Process Model (McDaniel & Einstein, 2011) and with research concerning another clinical population (Morgan et al., 2012; Poquette et al., 2013).

The clinical implications of this relationship are potentially significant. These data suggest that a more thorough investigation of pain in people with MS is warranted. Specifically, if pain could be controlled, patients with MS may be better able to remember ongoing life events, thereby improving memory for future behaviors.

Further, it may be helpful to examine the relationship of pain with other aspects of neuropsychological functioning. In addition to memory dysfunction, those with MS show impairment in the domains of working memory, attention, and executive function. The extent to which pain affects these specific cognitive resources is unknown. Furthermore, the effects of poor PM on the functional outcomes of people with MS should be investigated. For example, Poquette et al. (2013) found that MIST performance predicted treatment

adherence among individuals with HIV. Possibly, MIST performance may likewise predict treatment adherence or other functional outcomes in individuals with MS.

Despite the compelling relationship between self-reported pain and impairment on a prospective memory task, the current study has several limitations. First, the control group significantly differed from the patients. Specifically, the two groups differed on age, with the MS group reporting a higher mean age than the control group ($M = 45$ years and 40 years respectively). This difference notwithstanding, we statistically controlled for potentially confounding effects of age, and pain severity emerged as a significant predictor of poor prospective memory.

Second, among the patients with MS, the majority of patients in our sample, approximately 64%, included those who were diagnosed with the relapsing-remitting subtype. The remainder was comprised of a mixture of disease subtypes. Some literature has demonstrated that cognitive dysfunction, specifically memory impairment, may differ by disease type (Gaudino, Chiaravalloti, DeLuca, & Diamond, 2001), with worse dysfunction occurring among patients with a primary-progressive course. Owing to a limited sample size, our data do not permit a careful evaluation of whether disease subtype may moderate the observed effects of pain on prospective memory. It may be worthwhile to evaluate this in future research.

Third, the present study did not measure self-reported levels of fatigue. As much as 96% of individuals with MS report significant difficulties involving fatigue (Shah, 2009). It is possible that fatigue may account for unique variance in MIST scores. Nonetheless, several studies have found no compelling relationship between self-reported fatigue and cognition in people with MS (Strober & Deluca, 2013; Krupp & Elkins, 2000; Paul, Beatty, Schneider, Blanco, & Hames, 1998; Beatty et al., 2003). Finally, it should be acknowledged that the PES only assesses severity of pain and its impact on functioning. As such, the present study cannot offer details concerning location or type of pain. Future research might address whether such characteristics possess more salient relationships with prospective memory than an overall summary score.

Despite these limitations, this is the first investigation, to our knowledge, that has addressed the relationship between self-reported pain and prospective memory in people with MS. While it has been shown that individuals with MS frequently report experiencing pain and memory dysfunction, these data imply that higher levels of self-reported pain correspond with diminished cognitive functioning. Collectively, these data support the theory that pain distracts individuals from attending to their intentions, leading to worse memory to perform future actions.

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Table 1

Demographic Characteristics of Participants

	MS N = 96	Control N = 29
Gender:	75 (78%) Females 21 (22%) Male	19 (66%) Females 10 (34%) Males
Age:	45.5 (10.5)	38.9 (12.2)
Diagnostic subtype:	62 (64%) relapsing remitting 9 (9%) secondary progressive 2 (2%) primary progressive 3 (3%) progressive relapsing 20 (21%) uncertain	
Education:	14.4 (2.3)	14.3 (2.3)
Ethnicity :	87 (90%) Caucasian 3 (3%) African-American 4 (4%) American Indian 1 (1.0%) Hispanic 1 (1.0%) Declined	26 (90%) Caucasian 1 (3%) African-Americans 1 (3%) Asian-American 1 (3%) Declined

Note. Standard deviations or percentages appear in parentheses.

Table 2

Means and Standard Deviations on CMDI, Timed 25 Foot Walk, and Pain Severity for all Participants

CMDI Scale	MS	Control
CMDI Mood **	55.6 (14.2)	48.0 (7.4)
CMDI Evaluative *	56.3 (17.8)	48.5 (8.9)
CMDI Vegetative **	65.0 (12.8)	51.9 (12.2)
25-foot walk in seconds **	20.7 (45.4)	4.5 (0.8)
Pain severity **	16.7 (6.5)	10.7 (6.1)

Note.

*
 $p < .01$.**
 $p < .001$. CMDI = Chicago Multiscale Depression Inventory. Values represent means. Standard deviations appear in parenthesis.

Table 3

Descriptive Statistics on MIST Scales for all Participants

MIST Scale	MS	Control	F-Test Group	F-Test Age
MIST Total Score	38.4 (0.7)	41.7 (1.3)	5.0 *	4.2 *
MIST 2-Minute Time-Based Memory	3.7 (0.1)	3.7 (0.1)	0.01	4.6 *
MIST 2-Minute Event-Based Memory	3.7 (0.1)	3.9 (0.1)	2.3	0.5
MIST 15-Minute Time-Based Memory	1.9 (0.1)	2.5 (0.2)	8.2 **	4.0 *
MIST 15-Minute Event-Based Memory	3.5 (0.1)	3.7 (0.2)	0.8	1.9
MIST Time-Based Memory	5.6 (0.1)	6.2 (0.3)	4.4 *	6.5 **
MIST Event-Based Memory	7.2 (0.1)	7.6 (0.3)	2.1	0.4
MIST Verbal Response	6.5 (0.1)	7.1 (0.2)	3.5	3.8
MIST Action Response	6.3 (0.1)	6.8 (0.3)	3.4	2.3
MIST Recognition Score	7.8 (0.1)	7.7 (0.1)	0.01	3.2

Note. F-test results reflect oneway analysis of covariance. Participant group served as the between groups variable, and age served as the covariate. $df = 1,121$.

* $p < .05$

** $p < .01$. MIST = Memory for Intentions Screening Test. Values represent estimated means after correcting for age. Standard errors appear in parentheses

Table 4

Regression Results: Semi-Partial Correlations for All Independent Variables Across MIST Scales

MIST Scale	Age	Education	Sex	Pain Severity	25-Foot Walk	CMDI Mood
MIST Total Score	−0.12	0.08	−0.03	−0.31**	−0.16	.16
MIST 2-Minute Time-Based Memory	−0.18	0.06	0.05	−0.11	−0.05	.02
MIST 2-Minute Event-Based Memory	0.09	0.13	−0.15	−0.10	−0.13	−.00
MIST 15-Minute Time-Based Memory	−0.13	−0.30	0.04	−0.33**	−0.13	.17
MIST 15-Minute Event-Based Memory	−0.06	0.08	−0.04	−0.21	−0.09	.17
MIST Time-Based Memory	−0.19	0.01	0.05	−0.29*	−0.12	.14
MIST Event-Based Memory	0.00	0.13	−0.11	−0.20	−0.13	.12
MIST Verbal Response	−0.17	0.09	−0.04	−0.23*	−0.14	.06
MIST Action Response	−0.05	0.05	−0.07	−0.28*	−0.12	.19
MIST Recognition Score	−0.13	−0.03	0.03	−0.18	−0.03	−.08

Note. $df = 118$.

* $p < .01$.

** $p < .001$.