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Cognitive and Emotional Correlates of Improved Gait Distance During the Course of Physical Therapy Treatment for an Incomplete Spinal Cord Injury

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By

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Abstract

Danielle O. Miller *Cognitive and Emotional Correlates of Improved Gait Distance During the Course of Physical Therapy Treatment for an Incomplete Spinal Cord Injury*, Department of Neuroscience, June 2018.

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Objective

The focus of spinal cord injury rehabilitation over the past four decades has shifted from medical management to issuses that affect quality of life and community participation (Gómara-Toldrà, Sliwinski, & Dijkers, 2014). However, the care team for spinal cord injury patients still need to collaberate in order to design and implement interventions that result in maximum participation to provide an individual with a spinal cord injury an effective rehabilitation program. In order to create such a rehablitation program, the care team must know how certain psychological and cognitive aspects, such as depression and implict memory, are related to the course and out comes of physcial therapy treatment. The aim of this pilot study was to complie research concerning how depression and implicit memory are related to the physical therapy outcomes of an individual with a spinal cord injury.

Design

The study team administered a battery of psychological tests to two control groups, one consisting of younger individuals and the other consisting of older individuals, and a patient group. These tests were administered on two separate occassions to both control groups and on four separate occassions to the patient group. The data collected was annalyzed by runing repeated measure ANOVAs, appropriate post-hoc tests, and partial correlation tests.

Results and Conclusions

There was no way to normalize the physical therapy improvement data for patients. This was the result of there not being a universal approach to treating incomplete spinal cord injuries and documenting improvement rates. However, the study team did find effects related to symptoms of depression and implicit memory ability across the patient and healthy control groups. Specifically, the patient group had greater symptoms of depression compared to either the younger or older control groups, and the older control group had the slowest implicit memory compared to either the younger control group or patient group.

Table of Contents

Introduction

A spinal cord injury compromises the processing of motor, sensory, and/or autonomic reflexes (Dumont et al., 2001). Each year, over 8000 people in the United States suffer from a traumatic spinal cord injury (Wirz et al., 2005), and there are currently over 200,000 individuals living with a chronic spinal cord injury (Anderson, 2004). Chronic spinal cord injuries not only impact sensorimotor processing, but also have profound effects on an individual's economic situation as well as their psychological and physiological state (van Middendorp et al., 2011). Although these injuries are not typically reversible, advances in science and technology have led to improved quality of living for individuals with a spinal cord injury. Today, these people have improved survival rates, increased opportunities for independent living, and longer life spans compared to those a decade ago (Anderson, 2004).

The Role of Psychological Intervention in Rehabilitation

Despite these advances, chronic pain has a profound impact on quality of living (Hadjipavlou, Cortese, & Ramaswamy, 2016). Chronic pain impacts about 70% of spinal cord injury patients, is poorly understood, and is further complicated by the psychosocial impact of the injury (Hadjipavlou et al., 2016). Research suggests that treatment strategies for chronic pain are not effective in isolation and often need to be combined with pharmacological methods, physical therapy, and psychological input in specialist center (Hadjipavlou et al., 2016). For instance, a study conducted by researchers from the Mayo Clinic Department of Pain Management found that comprehensive interdisciplinary rehabilitation – which is comprised of physical therapy, occupational therapy, and cognitive behavioral therapy – can significantly improve functioning in people living with chronic pain compared to stand-alone therapies

(Kurklinsky, Perez, Lacayo, & Sletten, 2016). Although functional improvement was associated with a considerable increase in a patient's perception of quality of life issues, this research was not done with spinal cord injury patients.

The knowledge obtained from the research described above has opened the door for the possibility of developing improved treatment for a spinal cord injury. However, there is little data to support or refute the idea that psychological intervention in combination with rehabilitation therapy is effective in improving the condition of individuals living with a spinal cord injury (Craig, Hancock, Dickson, & Chang, 1997). Research analyzing the impact of psychological intervention in combination with physical therapy could lead to developing care plans that further improve the quality of life for spinal cord injury patients.

Developing care plans that treat psychological disorders such as depression and anxiety in spinal cord injury patients could be essential in bettering the quality of life for these patients. This claim is supported by findings which suggest that an individual's pain intensity and pain catastrophizing, which are factors that influence the onset and experience of chronic pain, are positively correlated with clinically diagnosed anxiety and depression symptoms (Behrman, Bowden, & Nair, 2006). These findings are supported by research which suggests that depression, anxiety, and chronic pain is strongly associated with more severe pain, greater disability, and poorer health-related quality of life (Bair, Wu, Damush, Sutherland, & Kroenke, 2008). The claim can also be supported by a body of research that suggests that psychological symptoms such as depression and anxiety are highly associated with diminished health status and increased health care use (DiMatteo, Lepper, & Croghan, 2000). For instance, a meta-analysis that focused on the relationship between depression and medical compliance found that patients who have depression are more likely to be noncompliant with medical recommendations than patients who

do not have depression. Finally, research suggests that psychological factors could have an impact on an individual's memory, which plays an essential role in physical therapy (Besche-Richard, 2013). Given the impact of psychological factors on rehabilitation and quality of life, research should be conducted to see their potential influence on spinal cord injury physical therapy outcomes.

The Role of Implicit Memory in Rehabilitation

As stated above, memory plays a crucial role in physical therapy treatment (Besche-Richard, 2013). Given its role, a possible influential component of spinal cord injury physical therapy could be an individual's procedural implicit memory (a specific type of unconscious memory). Procedural implicit memories are formulated with recurrent practice of a task and do not require that the learner develop conscious rules to guide performance (Ford & Bickel, 2012). In reference to spinal cord injury rehabilitation, an individual's procedural implicit memory is essential when he or she is re-learning how to use their body. Given the significant role of procedural implicit memory in physical therapy, research should analyze whether an individual's procedural memory influences spinal cord injury physical therapy outcomes. Therefore, it is possible that understanding the influence of procedural implicit memory on the course of physical therapy might help clinicians make better decisions and predictions about an individual's rehabilitation program.

As mentioned, research suggests that psychological factors impact an individual's memory. For instance, findings have characterized depression by a variety of behavioral, emotional, and cognitive symptoms especially in the domain of memory (Besche-Richard, 2013). In the past two decades, there has been an increased research interest in the area of depression

and implicit memory (Besche-Richard, 2013). Unfortunately, the literature concerning depression's effects on implicit memory has not allowed for researchers to reach a consensus (Besche-Richard, 2013). This is due to the fact that in the past three decades, research studies investigating depression and implicit memory have found conflicting relationships among depression levels and implicit memory. Some have found no significant differences in implicit memory tasks by depressive status, while others have found that depressed individuals performed worse than controls on an implicit memory tasks (Besche-Richard, 2013). Given the roles of implicit memory and psychological factors on physical therapy, analyzing the relationship between implicit memory and depression could be beneficial in developing a better treatment for spinal cord injury patients.

The Purpose of the Prospective Pilot Study

The aim of this prospective pilot study is to begin to accumulate data that will allow for a better understanding of the inter-relationship between depression levels and implicit memory of an individual living with a chronic spinal cord injury. This will be assessed in relation to improvements in gait (walking) distance while the patient is receiving physical therapy treatment. This information could be beneficial for developing new approaches for making better, more accurate, decisions and predictions about future rehabilitation programs.

In reference to depression levels and physical therapy improvements, the study team predicted that depression levels will be negatively correlated with improved gait distance. Individuals with higher levels of depression are expected to have less improvement in gait distance than individuals reporting fewer symptoms of depression. This hypothesis stems from

findings that suggest that individuals who have higher levels of depression are less compliant and motivated than individuals who have low levels of depression, as discussed above.

In reference to implicit memory scores and physical therapy improvements, the study team predicted that implicit memory would be positively correlated with improved gait distance. So, if an individual is found to have more improved implicit memory scores, we expect that he or she will have more improvement in gait distance throughout therapy.

In order to successfully study depression and implicit memory in spinal cord injury patients, it is essential to compare their level of depression and implicit memory to the general population. However, research has shown that depression and implicit memory are dependent on many factors, one major factor being age. Given the potential impact of age, two control groups were studied consisting of younger individuals (college students) and older individuals (65 and older) to compare the patients' depression levels and implicit memory to.

In reference to depression levels, the research study team predicted that the younger control group would have the lowest depression level scores, the older control group would have the second lowest depression level scores, and the patient group would have the highest depression level scores. This hypothesis is based on a body of research supporting the notion that depression is often comorbid with chronic illnesses such as a spinal cord injury (Moussavi & Chatterji, 2007). The prediction is also based on findings that suggest that depression levels tend to increase with age (Blazer, Burchett, Service, & George, 1991).

In reference to implicit memory, the research study team predicted that the younger control group would have the fastest implicit memory to begin with, the older control group would have the second fastest implicit memory to begin with, and the experimental group would have the slowest implicit memory to begin with. The rationale behind this prediction stems from

research that suggests that motor functioning tends to decline with age (Voelcker-Rehage, 2008). This hypothesis is also based on the fact that many spinal cord injury patients' upper body motor functioning is compromised (Nas, 2015). Additionally, the research team also believed that the younger control group would have the most improved implicit memory scores, the older control group would have the second most improved implicit memory scores, and that the patient group would have the least improved implicit memory scores. The rationale for this prediction is premised on the idea that high levels of depression are association with low motivation (Smith, 2013). So, since the study team predicted that the younger control group would have the lowest depression levels, the older control group would have the second lowest depression levels, and the patient group would have the highest depression levels, the study team believed that the younger control group would be the most motivated, and thus show the most improvement rates, and the patient group would be the least motivated, and thus show the least improvement rates.

Methods

Subjects and Recruitment

Three patients were recruited following the study's approval by the St. Peter's Health Partner's Internal Review Board and the Human Subjects Research Review Committee at Union College. Following approval, identification and the initial approach of potential participants was made by the patients' primary physical therapist. If the patient was interested in participating, their primary physical therapist referred the patient to one of the study's principal investigators. If the individual agreed to be involved in the study, they were asked to sign a Consent form and an Authorization (Permission) to Use or Disclose Identifiable Protected Health Information for Research form. Once the required forms were signed, the participant's medical records were

accessed through MedLinks. This was done to ensure that the patient met the study's inclusion criteria. The inclusion criteria for the patient group included having an incomplete spinal cord injury with an American Spinal Injury Association (AISA) Impairment Scale of grade C or D. The individual also had to be receiving physical therapy at least once a week for three months. Finally, since all tests were administered in English, the individual had to be able to read and write in English.

An ASIA Impairment scale grade C is considered an incomplete spinal cord injury. For a spinal cord injury to be classified as a grade C, the individual's motor function must be preserved below the neurological level, and more than half of the key muscles' strength must be below the neurological level and have a muscle grade less than 3 (key muscles are graded on a six-point scale 0=total paralysis; 1=palpable or visible contraction; 2= active movement, full range of motion with gravity eliminated; 3=active movement, full range of motion against gravity; 4= active movement, full range of motion against moderate resistance; 5= normal active movement, full range of motion against full resistance; and NT= not testable). A grade D spinal cord injury is also considered an incomplete spinal cord injury. To be classified as a grade D spinal cord injury, the individual's motor function must be preserved below the neurological level, at least half of the key muscles must be below the neurological level, and these key muscles below the neurological level must have a grade greater than or equal to 3.

Healthy participants of both control groups were recruited from Union College's student (n=12) or UCALL (n=6; Union College Academy for Lifelong Learning) club. One control group contained individuals who were between twenty and twenty-three years old. The other control group contained individuals that were sixty-five and older. All control group participants

had no prior psychological disorders or spinal cord injuries. Like the patient group participants, all control group participants were required to read and write in English.

Psychological Questionnaires

Once the study team ensured that the participant met the inclusion criteria, the study team set up a meeting with the participant to administer the battery of psychological tests. To answer the study team's main questions, the Beck's Depression Inventory (BDI) and the Mirror drawing Task were administered to all participants. Additional scales related to either the Beck's Depression Inventory or the Mirror Drawing Task were also administered in order to answer supplemental questions that these tests could not answer (see below).

The Beck Depression Inventory was administered to analyze participants' depression symptoms (Steer, Ball, Ranieri, & Beck, 1999). The scale is a 21-item self-reported multiple choice inventory (Beck AT, Steer RA, 1996). Participants were asked to rate the items on a 4-point scale (0-3) based on the severity of each item. The maximum score an individual could obtain was a 63. The higher the score, the higher the severity of depression.

The rationale behind administering the Beck's Depression Inventory was that it allows for the analysis of depression symptoms by including a scale that has cut-offs for clinical levels of depression. Although it allows for the analysis of depression symptoms, it does not include analysis of specific depression-related symptoms such as hopelessness. In addition, the Beck's Depression Inventory (BDI) does not measure an individual's Behavioral Inhibition System or Behavioral Approach System, which have been said to be linked to the course and severity of depression (Kasch, Rottenberg, Arnow, & Gotlib, 2002). Because of this the Beck Hopelessness Scale (BHS), which measures an individual's negative expectations regarding the future

(Minkoff, Bergman, Beck, & Beck, 2006), and the Behavioral Inhibition System/Behavioral Approach System (BIS/BAS) scale, which measures an individual's Behavioral Approach System and Behavioral Inhibition System (Steer et al., 1999), were administered. Since these scales concern aspects of depression that are not tested in the BDI, the study team administered these tests to analyze whether the aspects of depression tested in the BHS and BIS/BAS were correlated to the symptoms of depression tested in the BDI.

As mentioned in the introduction, high levels of depression are often accompanied with high levels of anxiety, fear of pain, and catastrophizing ideals concerning pain. Due to this relationship, the study team also administered the Anxiety Scale Index-3 (ASI-3) assessment, which is designed to measure an individual's anticipation and/or worry of potential future threats (anxiety) (Taylor et al., 2007), the Pain Catastrophizing Scale (PCS), which assesses an individual's level of catastrophic thinking in relation to pain related-variables (Sullivan, 2009), and the Fear of Pain (FOP) Questionnaire, which assesses an individual's fear across three categories of pain: Severe, Minor, and Medical Pain (Asmundson, Bovell, Carleton, & McWilliams, 2008). These scales would allow the study team to analyze whether the data collected supported the well documented relationship between levels of depression and levels of anxiety, fear of pain, and catastrophizing ideals concerning pain.

To test implicit memory, the study team administered the Mirror Drawing Task. The Mirror Drawing Task measures an individual's implicit memory. The task requires an individual to trace a diagram of a shape on a piece of paper while looking at the image as a reflection in a mirror (Julius & Adi-Japha, 2016). The assessment includes a mirror apparatus that consists of a box and a mirror. This apparatus allows the participant to see the page with the shape on it, but not see his or her hand.

The rationale behind administering the Mirror Drawing Task was to test an individual's implicit memory. Although research in implicit memory is vital for the progression of physical therapy treatment, it is essential to analyze whether an individual's cognitive functioning and explicit memory — the conscious recollection of facts, ideas, and events — is impaired (Ford & Bickel, 2012). This is because if a patient has impaired cognitive functioning or explicit memory, it may limit his or her understanding of what they need to do in order to perform the implicit memory task (Ford & Bickel, 2012). To ensure that a participant's cognitive functioning was not impaired and thus affecting implicit memory scores, the Montreal Cognitive Assessment was administered. To assure explicit memory was not impaired and thus affecting implicit memory scores, the Digit Span Task, which measures an individual's short-term verbal memory, was administered (Woods et al., 2012). After collecting these scores, the study ensured that all scores fell within or above the average range for normal cognitive functioning.

Combined Analysis

This battery of psychological tests was administered on two separate occasions in a quiet room to both the younger and the older control groups. The patient group was also given this battery of psychological tests in a quiet room. However, since the patient group consisted of three individuals, the patients were given these tests on four separate occasions. By administering the tests multiple times to each research group, it allowed for the research team to run a repeated measures ANOVA. This allowed for a much more powerful design than would be seen with a standard three-group comparison (and related t-tests) – in other words, the 'n' for the patient group is not 3 subjects but rather is n=12 for patients (3 patients over 4 visits), n= 24 for the younger control patients (12 subjects over 2 visits), and n= 12 for the older control patients (6

subjects over 2 visits). The administration of these tests to all research groups occurred ten to sixteen days apart.

Additionally, a Demographics Questionnaire and the Marlowe-Crowne Social Desirability Scale, which was given to ensure that participants were not likely to give socially desirable answers, was administered in one of the sessions.

Once all data was collected, the study team ran a repeated measures ANOVA for each of the tests administered. If the analysis uncovered a time by group interaction or a main group effect, the study team ran the appropriate post-hoc test to determine which means were significantly different from the others. For this study, the alpha-threshold for determining significance was 0.05. Three separate partial correlations were run. One between BDI scores and BHS, BAS/BIS scores, another between BDI scores and ASI-3, PCS, and FOP scores, and finally one between Mirror Drawing task scores and BDI scores. All analyses were performed using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

Results

BDI

Results from a repeated measures ANOVA showed that across groups there was a significant time by group interaction ($p=0.05$) (Table 1). To assess the time by group effect, the study team ran a repeated measures ANOVA post-hoc test. The results showed that the control groups were significantly different from the patient group (Figure 1). The results also showed that BDI scores changed across time for the patient group but not for the younger or older control group (Figure 1b).

BDI RM ANOVA Within-Subject Contrasts Findings

Source	Significance (p value)
Time *Age	.045 *
Time * Education	.773
Time *Sex	.888
Time * Marlowe-Crone Social Desirability Scale	.412
Time * Group	.050 *

Table 1. BDI RM ANOVA Within Subject Contrasts Findings. The asterisks (*) indicate significant findings ($p<0.05$) following a RM ANVOA. There was a significant time by age effect and a significant time by group effect.

Figure 1 reveals a significant difference in the younger (5.2±3.4) and patient (9.8±6.6) mean group scores as well as the older (5.7± 4.1) and patient mean group scores. This supports the research group's hypothesis that patient BDI scores would be the highest. However, the research team did not expect the younger and older control group BDI scores to not be significantly different.

Since the patient group is only composed of three individuals, it does not have a lot of variability. This could cause patient scores to drive the results of the post-hoc test. To ensure that the patient data was not driving the results, an additional RM ANOVA test was run between the younger and older control group scores. The results showed that there was no significant time by group effect, meaning that the patient scores were what was driving the first RM ANOVA results of a significant time by group effect. This led to the study team analyzing patient BDI scores. The study team found that the BDI scores significantly differed from time one of administration to time two of administration (Figure 1b).

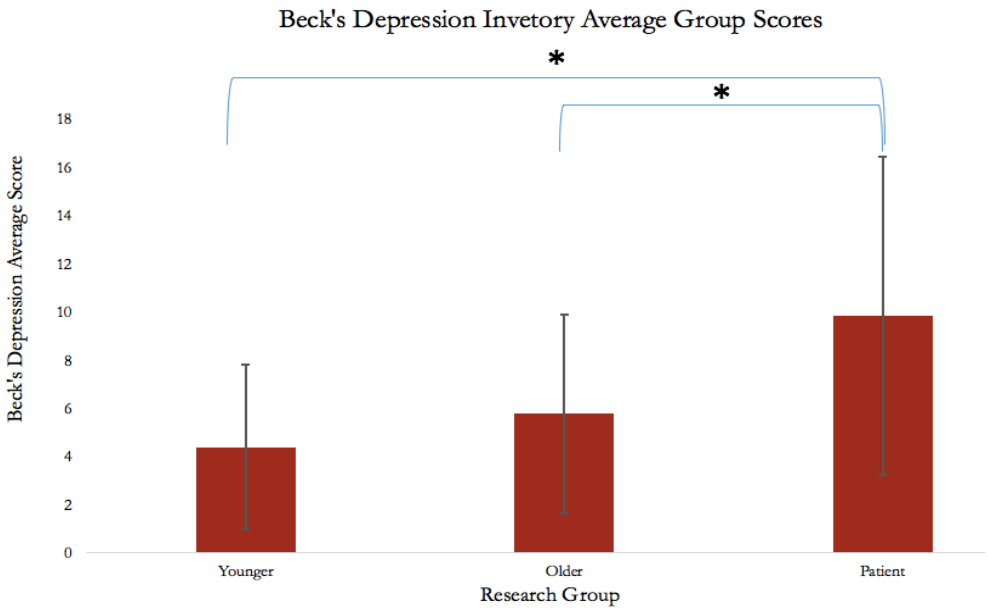

Figure 1. Average BDI Research Group Scores. The asterisks (*) indicate significant findings ($p<0.05$) following RM ANOVA and post-hoc tests. The results indicate a significant difference in the patient group and older control group BDI scores and patient group & younger control group BDI Scores.

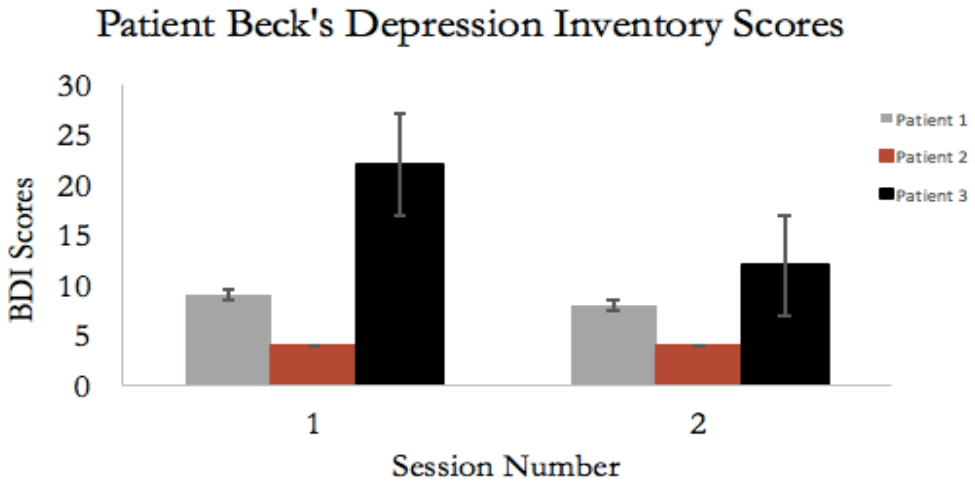

Figure 1B. Patient BDI Scores Across Session 1 and 2. The results indicate a significant difference in the patient group scores across session one and session two. The scores significantly decrease from session one to session two.

Mirror Drawing Task

Results from a repeated measures ANOVA showed that there was not a significant group effect or time by group interaction. Although there was no significant time by group

interaction, the results suggest that each group does improve from the first administration of the test to the second administration of the test (Figure 3).

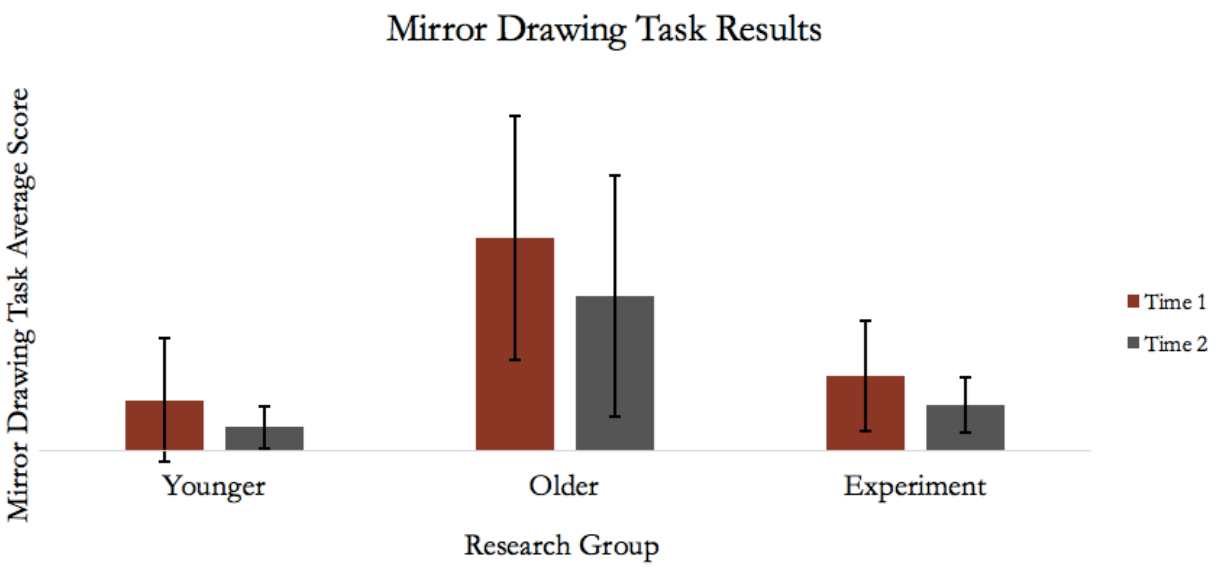

Figure 3. Mirror Drawing Task Scores Across Time. This graph illustrates that there is an improvement trend across all groups between the first administration of the test and the second administration of the test.

The study team decided to run a post-hoc test to analyze whether there was a difference in group scores. To run this test, the study team took the average Mirror Drawing Task scores across time for each research group. Figure 4 is a graphical representation of the results from the post-hoc test of the average Mirror Drawing Task scores across time. The graph reveals a significant difference in the younger control group (2.4±2.6) and older control group scores (12.4±5.9) and the older control group and patient group scores (4.0±2.7). Since there was not a significant difference between patient and younger control group scores, these results do not support the study team's hypothesis that the younger group would start off with the lowest mirror drawing task scores and the patient group would begin with the highest mirror drawing task scores.

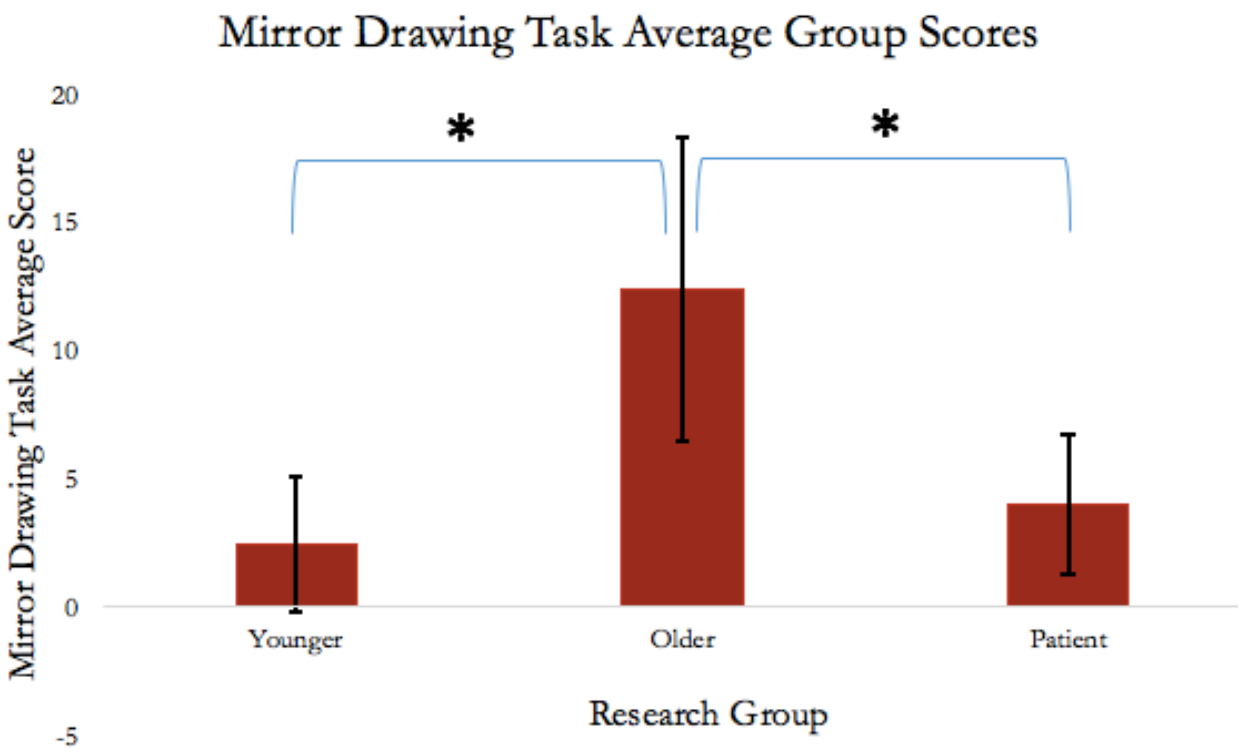

Figure 4. Average Mirror Drawing Task Scores. The asterisks (*) indicate significant results ($p<.005$). This graph illustrates that there is a significant difference between younger and older control group mirror drawing task scores and older control group and patient group Mirror Drawing Task scores.

Cognitive functioning

The study team decided to administer the Digit Span Task and the Montreal Cognitive assessment in order to ensure that an individual's cognitive functioning was not driving the results. To do this the team looked at all Montreal Cognitive assessment and Digit Span Task scores. The team found that scores for both tests were within or above the range of the average individual. These results showed that the participant's cognitive functioning was not driving the results. The study team also ran a repeated measures ANOVA for both the Digit Span Task and the Montreal Cognitive assessment. The team found that there was not a significant difference in group scores across time.

Mirror Drawing Task scores and BDI Scores

The study team ran a repeated measures ANOVA to analyze whether the first BDI scores were indicative of improved Mirror Drawing Task scores. The results revealed no interaction between first BDI scores and Mirror Drawing Task scores.

Since the patient group showed a time by group effect for the BDI tests, the study team wanted to analyze separately whether patient BDI scores were related patient Mirror Drawing Task scores across sessions. To analyze whether Mirror Drawing Task improvement scores for all patients was correlated to an individual's BDI scores, the study team ran a partial correlation between Mirror Drawing Task Improvement scores and BDI scores. The study team found that the scores were not significantly correlated (Figure 5).

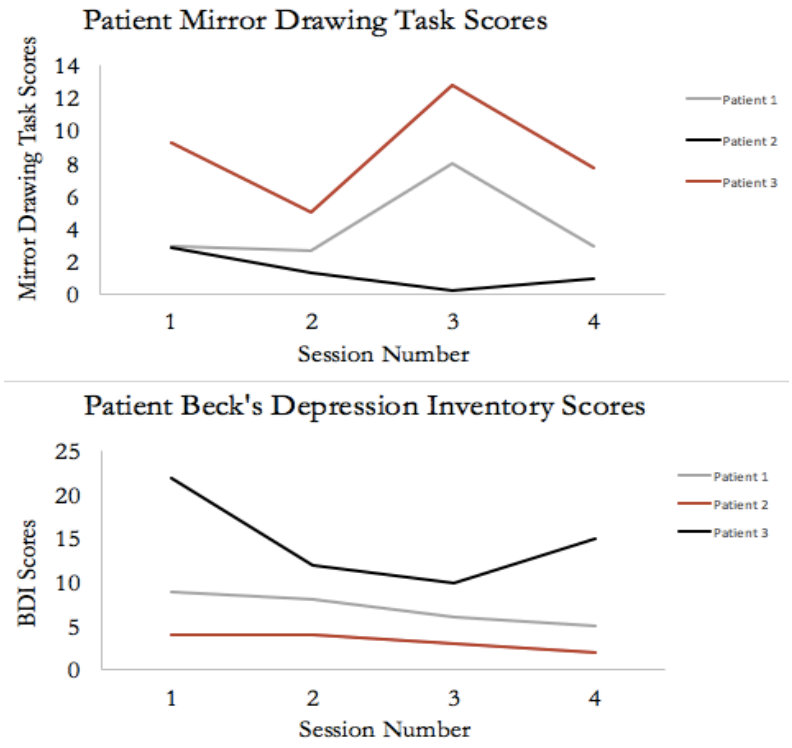

Figure 5. Patient Mirror Drawing Task Scores and BDI scores. This is a depiction of all three patient's BDI and Mirror Drawing Task scores across four sessions. There is no correlation between BDI scores and Mirror Drawing Task Scores. Both Mirror Drawing Task scores and BDI scores vary across sessions.

Control and Exploratory Analysis

Table 2 illustrates the results of a partial correlation where each research group served as a control and the variables were the average BDI, FOP, PCS, & ASI scores. The only significant correlation with BDI scores was ASI-3 scores (r=.49) (Figure 6).

Correlation between Average BDI Scores and Average ASI-3, PCS, & FOP Scores

	Average ASI-3 Scores	Average PCS Scores	Average FOP Scores
Correlation Significance With Average BDI Scores	f= .492 p= .028*	f= .439 p= .053	f= .037 p= .887

Table 2. Correlation between Average BDI Scores and Average ASI-3, PCS, & FOP Scores. The asterisks (*) indicate significant findings ($p<0.05$) following a partial correlation. The only significant p value was for the correlation between average BDI scores and average ASI-3 scores. Since the value was significant, so was the f value.

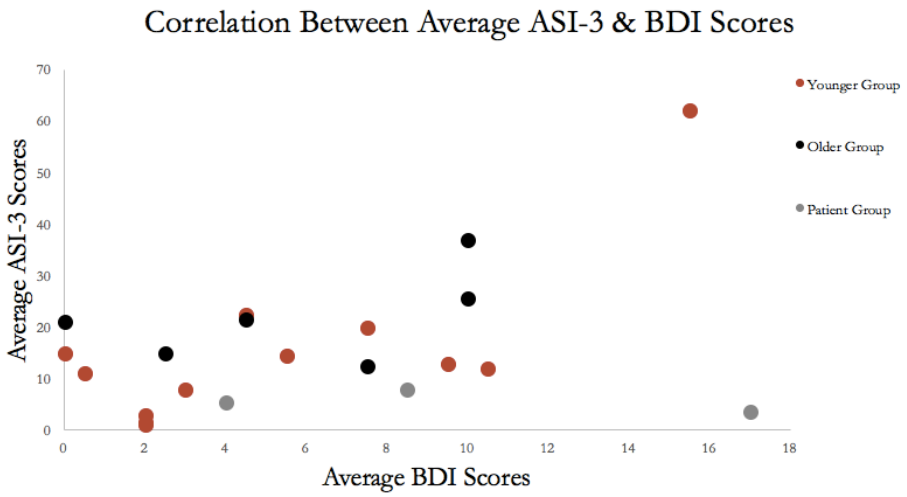

Figure 6. Correlation Between Individual Average ASI-3 & BDI Scores. This graph illustrates that as average ASI-3 scores increase so do average BDI scores. This trend is seen across all three experimental groups.

Results from the partial correlation between average BDI, ASI-3, PCS, and FOP scores also revealed that there was a significant correlation between FOP scores and PCS scores ($p=.013$) and PCS scores and ASI-3 scores ($p<.001$).

Prior to the partial correlation, the study team ran a repeated measures ANOVA for ASI-3, PCS, and FOP scores. This was done to analyze whether there was a significant group effect or time by group effect. There was no significant group effect or time by group effect for ASI-3 scores, PCS scores, and FOP scores.

Table 3 illustrates the results of the partial correlation where the research group was the control and the variables were the average BDI, BHS, & BAS/BIS scores. The only significant correlation with BDI scores was BHS scores ($p=.008$) (Figure 7).

Correlation between Average BDI Scores and Average BHS, & BAS/BIS Scores

	Average BHS Scores	Average BAS Scores	Average BIS Scores
Correlation Significance With Average BDI Scores	f= .578 p= .008*	f= .190 p= .422	f= .363 p= .116

Table 3. Correlation between Average BDI Scores and Average BHS, & BAS/ BIS Scores. The asterisks (*) indicate significant findings ($p<0.05$) following a partial correlation. The only significant p value was for the correlation between average BDI scores and average BHS scores. Since the value was significant, so was the f value.

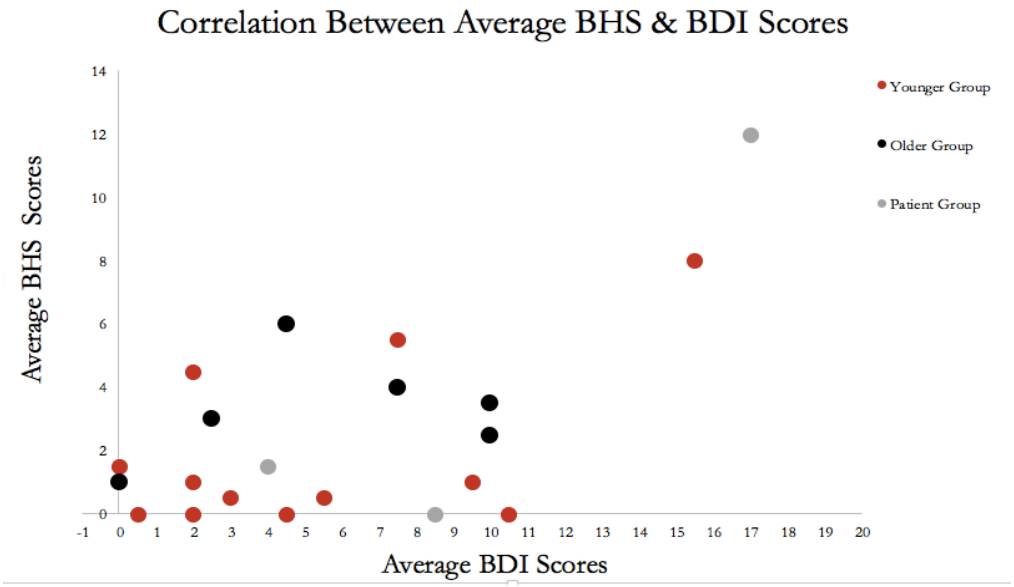

Figure 7. Correlation Between Individual Average BHS & BDI Scores. This graph illustrates that as average BHS scores increase so do average BDI scores. This trend is seen across all three research groups.

Prior to the partial correlation, the study team ran a repeated measures ANOVA for BHS and BAS/BIS scores. This was done to analyze whether there was a group effect or time by group effect. There was no significant group effect or time by group effect for BHS, BAS, and BIS scores.

Discussion

Summary of Findings

In summary, we found effects related to symptoms of depression and implicit memory ability across our patient and healthy control groups. Specifically, patients had greater symptoms of depression compared to either the younger or older control groups, and the older control group had the slowest implicit memory compared to either the younger control group or patient group.

BDI and Mirror Drawing Task Findings

The study team predicted that there would not be a significant time difference for BDI scores across sessions. However, the study team did not predict older and younger control group scores would be the same. This prediction was based on literature that suggested that depression levels tend to increase with age (Blazer et al., 1991). This unpredicted outcome could be due to the fact that the UCALL group is not an ordinary older group of individuals. The UCALL group was generally healthy; they've opted to take college classes; they are a social group of individuals; and they all have advanced degrees – much higher than the average population. Since education is a predictor of lower BDI scores in older age and also with increased general health and well-being, this could explain why younger and older control groups scores were not significantly different.

The results from the Mirror Drawing Task data from the first two sessions of all research groups show that there was a significant difference between older control group scores compared to either younger control group and patient group scores. The research team did not expect that the older control group would have the slowest implicit memory when compared to the younger control group and patient group scores. In addition, the study team did not expect that the younger control group would have a similar implicit memory speed to the patient group. This outcome could be due to the fact that the younger patient group was much larger than the other two research groups.

Additionally, results for the Mirror Drawing Task scores did not significantly change over the administration of tests. This result goes against the well supported finding that Mirror Drawing Task scores should increase over time. Although there was not a significant score difference across sessions, the study team did see an improvement trend from session one to

session two across all groups. The study team believes that if the test was given more than twice to the younger and older control groups, then there might have been a significant time difference. The Mirror Drawing Task scores for patients across the four testing sessions did not show any type of trend. A possible reason for this outcome could be due to the fact that the test was administered every 10-14 days. This gap of time might have been too long for individuals to show implicit memory improvements. Future studies should analyze whether there is a certain time period in which the Mirror Drawing Task should be administered in order to see improvement in scores.

The study team's question of whether BDI scores and Mirror Drawings Task scores were correlated to physical therapy improvements of a spinal cord injury was unable to be answered. This is because there was not a clear way of normalizing physical therapy improvement data. Part of the reason why this data was unable to be normalized was because there is not a universal approach for incomplete spinal cord injury physical therapy. This leads to different physical therapists using different approaches and techniques for treating an incomplete spinal cord injury. In addition, there is not a universal way of documenting physical therapy treatment outcomes. This inconsistency makes it hard to normalize physical therapy data.

Control and Exploratory Analysis Findings

Prior research studies found that depression, anxiety, pain catastrophizing and fear of pain are related. Research has shown that anxiety and depression are positively correlated. In addition, research supports that fear of pain and pain catastrophizing are indicators of current or future depression. Given these findings, the research team expected to find a significant partial correlation between BDI scores and ASI-3, FOP, and PCS scores. However, the study team only

found that there was a significant partial correlation between BDI and ASI-3 scores. One reason for this outcome could be because FOP and PCS scores only predict the maintenance and development of pain behaviors. So, someone who has higher FOP and PCS scores are at risk for more severe pain behaviors. It is the higher pain behaviors when experiencing pain that lead to higher levels of depression.

Given the relationship between BDI, BHS, and BAS/BIS scores, the study team expected to see a significant partial correlation between BDI and BHS and BAS/BIS scores. The only significant partial correlation was between BDI and BHS scores. A possible explanation for there not being a significant partial correlation between BDI and BAS/BIS scores is because the BAS/BIS scale is based on the controversial theory that depressed individuals are deficient in his or her Behavioral Approach System and have an overactive Behavioral Inhibition System. As stated this theory is disputed. Indeed, many believe that the theory is oversimplified. This could account for the reason why there was no significant partial correlation between BDI and BAS/BIS scores.

Physical Therapy Improvements

The inconsistency of documentation and various approaches to treating an incomplete spinal cord injury is problematic. One problem is that it is unknown whether all physical therapy treatments for incomplete spinal cord injuries are effective. Future research should focus on whether there are physical therapy techniques that have better outcomes than others. If it is found that certain techniques are better than others, then those techniques should be used to construct a universal approach for physical therapy treatment for incomplete spinal cord injuries. Since it is unknown whether there are better physical therapy treatments and approaches, physical therapist

sometime default to administering treatments that are most cost effective and use the least amount of people to administer it. The study team ran into this problem. For instance, the original study question concerned whether BDI and Mirror Drawing Task scores are correlated with Clinical Locomotor Treatment, which is a physical treatment used to treat incomplete spinal cord injuries, improvements. However, the rehabilitation hospital where this study occurred stopped administering the treatment. The reason why the rehabilitation hospital stopped administering this treatment was because it required five hospital personnel to administer part of the treatment. Since it is not proven that Clinical Locomotor Treatment has better outcomes than other types of physical therapy treatments, there was no reason for the hospital to continue to administer the treatment.

Final results

To conclude, there is a need for more research in the physical therapy of an incomplete spinal cord injury. This research can lead to a universal approach to treating an incomplete spinal cord injury. A universal approach to treating an incomplete spinal cord injury could lead to a way to normalize data concerning incomplete spinal cord injury physical therapy improvements. Normalizing this data is essential in understanding the relationship between incomplete spinal cord injury physical therapy improvements, implicit memory and depression. Having this information is advantageous for developing an interdisciplinary approach for treating an incomplete spinal cord injury. Having an interdisciplinary approach to treating an incomplete spinal cord injury could be the best treatment given that it has great outcomes for the rehabilitation of other ailments.

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