Does Mental Status Moderate the Relationship Between Traumatic Brain Injury History and Life Satisfaction?

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DOES MENTAL STATUS MODERATE THE RELATIONSHIP BETWEEN TRAUMATIC BRAIN INJURY HISTORY AND LIFE SATISFACTION?

by

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ABSTRACT

Traumatic brain injury (TBI) history has been linked to reduced cognitive performance and poorer quality of life. While this link has been established, there is not much known about this relationship in older adult populations experiencing normal cognitive decline. In the current study, mental status was predicted to moderate the relationship between TBI history and life satisfaction among older adults. Additionally, details of the injury - years since injury and time spent unconscious - were expected to play a role in this relationship. The sample consisted of 320 respondents, 58% women, from 2014 cohort of the Health and Retirement Study (HRS), with 134 reporting at least one TBI in their lifetime. Respondent's age ranged from 58 to 94 (M = 75.78, SD = 6.88). There were no significant relationships found between any of the TBI variables with mental status, life satisfaction, or the interaction of the two. While insignificant, these results yield important findings. The results lend support to more positive long-term outcomes for those with a history of TBI than initially expected, especially if the TBI was mild and resulted in no loss of consciousness or a loss of consciousness less than 5 hours.

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INTRODUCTION

Older adults can experience mild cognitive decline due to normal aging processes. In healthy individuals, crystalized intelligence (well-practiced and familiar skills, ability, and knowledge) typically remains intact, or improves, throughout older adulthood (Harada, Love &Triebel, 2013). However, fluid intelligence tends to decline after the third decade of life (Harada et al., 2013). Fluid intelligence involves gaining new information, processing, learning, and reasoning. Similar declines in fluid intelligence are seen in populations, of different age groups, who have experienced a traumatic brain injury (TBI) in their lifetime. Although effects on cognitive ability vary between individuals and time elapsed since the TBI, on average most cognitive improvement occurs in the first year post-injury; although some cognitive deficits can remain, and in some cases worsen, after another four years (Millis et al., 2001). Specifically, Millis et. al (2001) found that after examining performance on 15 neuropsychological tests, greatest improvement was seen in areas of cognitive speed, visuo-construction, and verbal memory while memory functioning, attention, and processing speed were most likely to decline in those who showed a decrease in cognitive functioning.

TBIs have been shown to exacerbate the natural cognitive decline in older adults, particularly with vigilance, memory, and frontal lobe functioning (Moretti et al., 2012). Even mild TBIs (i.e., concussions) have been shown to accelerate cognitive aging (Moretti et al., 2012) in these domains. Additionally, older adults who have ever experienced a TBI scored lower on the Mini-Mental State Examination (MMSE) and made more errors on executive functioning tasks than their control counterparts (Ozen, Fernandes, Clark & Roy, 2014).

TBIs have also been linked to other negative outcomes later in life such as reduced ability to work (Theadom et al., 2017) and decreased social skills (Janusz, Kirkwood, Yeates, & Taylor, 2002). In older adults without a TBI history, quality of social network has been found to be an influential factor for life satisfaction, along with cognitive status and self-reported health, which were both moderately associated with life satisfaction (Berg, Hassing, McClearn & Johansson, 2006). Subsequently, a person's quality of life can decline after experiencing a TBI (Hawthorne, Gruen, & Kaye, 2009; Anderson, Brown, Newitt, & Hoile, 2011; Andelic et al., 2009). Decreases in cognitive impairments, resulting in reduction of work ability (Theadom et al., 2017), social engagement (Janusz et al., 2002), and other factors, can lead to an overall decrease in quality of life and, in turn, life satisfaction. Severity of a TBI also influences these relationships, as in one study, those who experienced severe TBI reported significantly lower quality of life 13.3 years (on average) after their injury, as compared to those with mild or moderate TBIs (Anderson et al., 2011). Although the authors reported that mild and moderate TBIs had a more benign effect on quality of life, the participants recruited for this study were aged between 19 and 30 at the time of the study and experienced their TBI before the age of 16; in turn, the benign effects seen in this study cannot be assumed to replicate in an older adult population, who are also experiencing normal cognitive decline that comes with entering older adulthood.

Cognitive functioning has been evaluated in different ways in the existing research on this topic, most commonly using a variety of neuropsychological measures (Dean and Sterr, 2013; Levin et al. 1979; Millis et al., 2001). In the current study, mental status is measured using a modified version of The Telephone Interview for Cognitive Status (Brandt, Spencer &

Folstein, 1988), which was adapted from the Mini-Mental State Exam (Folstein, Folstein & McHugh, 1975). While neuropsychological measures assess individual differences in a broad range of performance within specific individual areas of cognition, mental status instruments produce a single score reflecting potential problems with general orientation and gross cognitive functioning. In this study, overall mental status was used, rather than specific areas of cognitive performance, mostly due to available data from the Health and Retirement Study (HRS). While many of the cognitive batteries in the public HRS data offered subjective responses, the mental status measure is objective and has a scoring mechanism already in place.

Because factors that have been shown to reduce quality of life and life satisfaction are areas that can be damaged by TBI, we expect to see a relationship between TBIs and satisfaction with life. In a study conducted by Janusez et al. (2002), children who experienced a severe TBI showed less development of social problem-solving skills than those who experienced a less severe TBI or a non-head-related injury, up to four years post-injury. These social impairments that can be caused by a TBI have also been linked to lower satisfaction with life (Gow, Pattie, Whiteman, Whalley & Deary, 2007). Gow et al. (2007) used the same Satisfaction with Life Scale used in the present study and found that social network/support factors, such as having a significant other, household composition, and loneliness, are related to reported life satisfaction.

Cognitive ability is also positively related to life satisfaction in healthy adults (St. John & Montgomery, 2010; Berg et al., 2006). Theoretically, individuals with a previous TBI who have higher mental status scores may report a higher life satisfaction than those with lower mental status scores. Higher mental status may serve as protective mechanism for life satisfaction and reduce the negative influence that a TBI can have on life satisfaction. Therefore, in this study we

expect to find that a previous TBI will reduce current satisfaction with life and that this relationship will be moderated by mental status.

In a similar study by Gardner, Langa, & Yaffe (2017), the authors found that respondents who experienced a TBI with loss of consciousness (LOC) were more likely to subjectively report poorer memory, although there were no differences in objective cognitive functioning between those with TBI or not, regardless of LOC. Gardner et al. (2017) used the same sample as the current study, the 2014 cohort of the Health and Retirement Study (HRS) and evaluated cognition by assessing episodic memory, attention, working memory, verbal semantic fluency, and calculation.. Although, they did not look at any measures relating to life satisfaction or quality of life and assessed general cognition rather than mental status. The samples only partially overlap due to the use of different variables. The current study only included participants who completed both the life satisfaction and mental status measures.

Many studies in the current and previous literature focus on outcomes of TBI less than five years post-injury (Banks et al., 2016; Dean & Sterr, 2013). Examining outcomes more than a few years post-injury can help evaluate the lingering effects of a TBI. There is also a gap in research regarding the relationship between life satisfaction, reduced cognition, and mental status caused by a TBI, in conjunction with normal cognitive decline as aging occurs. Examining the effects of a TBI is valuable given that a TBI can affect a person's wellbeing, cognition, and life satisfaction well after their injury. While existing research examines brain functioning and life satisfaction after a TBI mostly in regards to moderate and severe TBI, the present study will assess life satisfaction and mental status, in relation to all levels of TBI.

The present study aims to explore longer term relationships of mental status, life satisfaction, and TBI. The current study also takes into consideration participants' subjective satisfaction with life rather than objective quality of life, as the latter has been used as an outcome measure in most previous research in this domain. There is less known about how this subjective measure relates to TBI history, but could have significant implications for future research. Another source of novelty in this study is the use of an older adult sample. While research shows that cognition can be effected by a TBI, there are fewer studies that examine this effect in populations that are experiencing other cognitive changes due to aging.

The present study investigates the relationship between lifetime TBI, current life satisfaction, and current mental status in a sample of older adults. The hypotheses for this study are as follows:

Hypothesis 1: A history of at least one TBI will be related to lower mental status and lower life satisfaction, as compared to no history of a TBI.

Hypothesis 2: The severity of the most extreme TBI reported will be negatively related to life satisfaction and mental status.

Hypothesis 3: Time elapsed since the most recent TBI reported will be positively correlated with mental status and life satisfaction.

Hypothesis 4: Mental status will serve as a moderating variable between severity of TBI and reported life satisfaction. Specifically, reduced mental status will relate to an increase in the strength of the negative relationship between severity of TBI and reported life satisfaction.

Hypothesis 5: Mental status will serve as a moderating variable between time since most recent TBI reported and reported life satisfaction. Specifically, reduced mental status will relate to a decrease in the strength of the positive relationship between time since most recent TBI reported and reported life satisfaction.

METHODS

Participants

The sample used for the current study was from the 2014 cohort of the Health and Retirement Study (HRS). The HRS is sponsored by the National Institute on Aging and is conducted by the University of Michigan. This de-identified dataset is available for use by researchers through a website download. Participants consisted of adults who completed a traumatic brain injury questionnaire, a life satisfaction scale, and a mental status measure. Those who did not complete all three measures were excluded from the present study. One respondent was excluded because he/she reported a history of a gunshot through the brain. Additional respondents were removed from the dataset for being extreme outliers; this included two participants who indicated being unconscious for more than 24 hours following a TBI. This resulted in a final sample of 320 participants used in analyses.

Table 1: Descriptive statistics

	No TBI History	**With TBI history**
n	186	134
Sex (% Women)	67%	45%***
Age at Time of Study Completion	76.52(7.15); 58 to 94	74.77(6.38); 61 to 88*
Mental Status Total Score	11.84(2.41); 5 to 15	12.58(2.26); 7 to 15**
SWLS Total Score	26.51(8.39); 5 to 35	26.01(7.40); 5 to 35
Years Since Last TBI		38.69(22.86); 1 to 73

Longest Hours Unconscious from a TBI	0.32(0.64); 0 to 5

* $p < .05$, ** $p < .01$, ***$p < .001$ (difference between groups)
Unless otherwise indicated, cells represent mean(standard deviation); range
SWLS = Satisfaction with Life Scale; TBI = Traumatic Brain Injury

Materials

Satisfaction with Life Scale (SWLS). The SLS is a five item self-report questionnaire answered using a 7-point Likert Scale, with 1 being strongly disagree and 7 being strongly agree (Diener, Emmons, Larson, & Griffin, 1985). An example of a statement in the SWLS is "In most ways my life is close to my ideal." All items on the scale were found to have factor loadings greater that .61 (Diener et al., 1985). Total scores are calculated by adding the individual score for each item, making the least possible score 5 and the greatest possible score 35. The SWLS can be differentiated from many quality of life scales in the way that it requires a "cognitive-judgmental process" rather than relying on objective information about the respondent (Diener et al., 1985). The scale allows the individual to decide how satisfied they are with their life. The SWLS has good convergent validity, temporal stability, and discriminant validity from emotional wellbeing scales (Pavot & Diener, 2009). The SWLS was found to be highly reliable (5 items; $\alpha = .92$).

Modified Traumatic Brain Injury Questionnaire (MTBIQ). The MTBIQ consisted of a structured interview evaluating lifetime history of TBI. Participants were asked to report head injuries experienced due to specified causes and details of said injuries. These details include the age of the injury, the cause of the injury, and if loss of consciousness or memory loss was experienced (Corrigan & Bogner, 2007). If the respondents reported more than one TBI in the same category, then they were asked details of only one of the TBIs. It is not clear from the HRS

interview how a particular TBI was chosen for further questions if more than one was reported in a single category. The categories for cause of injury are as follows: vehicle accident, fall/being hit, sports/playing, hit/shaken, shot in the head, near explosion/blast. The interview resembles an abbreviated version of the Ohio State University TBI Identification Method (OSU TBI-ID), which research supports as a reliable and valid method of identifying TBI as well as evaluating the severity of these injuries (Corrigan & Bogner, 2007). For the present study, severity of TBI was defined as the longest reported duration of unconsciousness following any TBI. The duration since last TBI was estimated from subtracting age at time of concussion from the age at the time of completing the questionnaires. As the interview did not clarify how many total TBIs were experienced over a lifetime, we were limited when analyzing relationships with TBI frequency to whether participants experienced at least one lifetime TBI.

Customized Mental Status Assessment. Mental status was evaluated with a modified version of The Telephone Interview for Cognitive Status (Brandt, Spencer & Folstein, 1988), which was adapted from the Mini-Mental State Exam (Folstein, Folstein & McHugh, 1975) to be administered over the telephone. From this measure, the HRS used the serial 7's test, backwards counting (starting from 20), date naming, object naming, and President/Vice President naming. For the serial 7's test, respondents received 0 to 5 points and for the backwards counting respondents received 0 to 2 points. This measure was used as a general estimate of overall cognitive functioning and orientation, although the scale is only sensitive to individual differences at levels that indicate at least mild cognitive impairment. For all other questions respondents received a score of 0 or 1 for each question. Points were added to derive a total score, ranging from 0 to 15.

Procedure

The archival data from the 2014 HRS Core data release was downloaded from the publically available website. Participants who did not complete all three measures of interest in this study were removed from the dataset. Data analyses were performed using IBM SPSS software.

Statistical Analyses

Three linear regressions were performed to analyze the hypotheses. A binary logistic regression was used to examine the dependent variable of whether the participant reported at least one lifetime concussion. Two separate linear regressions examined the severity of the most severe TBI and the amount of time since last TBI as the dependent variable. For all regressions, age and sex were entered in block one, mental status and life satisfaction were entered in block two, and the interaction of the two was entered in block three. Main effects will be used to address hypotheses 1 and 2 and the interactions will address moderation from hypotheses 3 and 4. Beta values listed in Table 2 – 4 are unstandardized.

RESULTS

Participants who reported at least one lifetime TBI were significantly younger at the time of study completion and were more likely to be male, as compared with those denying a lifetime TBI (see Table 1). Younger participants also reported higher mental status, $r_s(320) = -.16$, $p = .004$. For these reasons, age and sex were included as covariates for all analyses.

Hypothesis 1 was evaluated using a binary logistic regression on the dependent variable of whether the participant reported at least one lifetime TBI (see table 2). Unexpectedly, the mental status score was higher in the participants reporting a history of at least one TBI as compared to those denying a history. There was no statistically significant main effect or interaction involving the life satisfaction score.

To evaluate hypothesis 2, for participants reporting at least one lifetime TBI, a linear regression was performed on the dependent variable of hours spent unconscious from the most severe concussion. There were no significant relationships found with the predictors (see table 3).

One additional regression was run, in the same fashion, on the dependent variable of number of years since the last reported TBI at the time of completing the survey. Likewise, no significant relationships were found with the predictors (see table 4).

Additionally, there was no support for hypotheses 4 or 5 as no significant interactions were found between life satisfaction and mental status across the three TBI variables.

Table 2: Binary logistic regression for TBI (traumatic brain injury) history (at least one TBI or no history of TBI)

	Block	β	p
Interaction (SWLS x MS)	3	< .001	.997
Satisfaction with Life Scale (SWLS)		-.004	.80
Mental Status Total Score (MS)	2	.12	.02
Age		-.04	.04
Sex	1	-.93	< .001

Table 3: Linear regression for hours spent unconscious from the most severe traumatic brain injury

	Block	β	p
Interaction (SWLS x MS)	3	.004	.32
Satisfaction with Life Scale (SWLS)		-.005	.53
Mental Status Total Score (MS)	2	.12	.49
Age		.007	.41
Sex	1	-.15	.18

Table 4: Linear regression for number of years elapsed since last reported traumatic brain injury at the time of data collection

	Block	β	p
Interaction (SWLS x MS)	3	.12	.37
Satisfaction with Life Scale (SWLS)		-.13	.64
Mental Status Total Score (MS)	2	-1.58	.08
Age		.01	.98
Sex	1	-6.03	.14

DISCUSSION

In contrast to all hypotheses, there were no expected main effects or interaction of satisfaction with life and mental status with any of the three TBI variables. We did find a statistically significant main effect for higher mental status scores in participants reporting at least one lifetime TBI, but this was the opposite direction than hypothesized. One possible theoretical explanation for the observed direction of this relationship is that individuals who experienced a previous TBI may have been more physically active which could have conferred a beneficial long term effect on cognitive performance. This effect may have been stronger than a potential negative long term effect from the TBI. Future research is needed to examine this theory. While the overall pattern of findings were unexpected, these results yield important findings. The results lend support to more positive long-term outcomes for those with a history of TBI than initially expected, especially if the TBI was mild and resulted in no loss of consciousness or a loss of consciousness less than 5 hours.

It is possible that there may have been more significant results if the sample included more respondents who reported severe TBI history. Two participants were excluded from the sample in this study that were outliers for hours spent unconscious. One respondent indicated being unconscious for one day, while the other reported being unconscious for two days. When these participants were included in analyses there was a stronger negative relationship with mental status; but, given that there were only two respondents who reported TBIs of this severity, they were removed from the sample. Previous research has found that those with more severe TBI suffered more impairments than their mild and moderate counterparts (Anderson et al., 2011; Thornhill et al., 2000). Additionally, Hoofien, Gilboa, Vakil, & Donovick (2001)

found that impairments from severe TBIs, that resulted in 14 days unconscious, on average, have been shown to negatively influence verbal learning abilities, recall abilities, processing speed, fine motor speed, and social functioning, even as long as 14 years after the injury.

In a study by Ettenhofer & Abeles (2009), there were no significant cognitive impairments relating to abstract reasoning, concept formation, set shifting, psycho-motor speed, attention, visual search speed, cognitive flexibility, semantic fluency, or word-learning associated with mild traumatic brain injuries up to 72 months post-injury. Given that the average number of years since injury in this study was 38.68, it is possible that full recovery may have taken place during this time, potentially within the first few years after the injury.

Some limitations should be noted. While the Mini-Mental Status Exam (MMSE) is a validated measure, the mental status measure for this study was adapted from a version of the MMSE intended to be given over the phone and not all the sections were administered. It is unknown if this customized measure was validated by the HRS or not. MMSE scores have also been used for dementia diagnoses (Kukull et al., 1994). In turn, lower scores on the mental status measure used for this study may have been closer linked with dementia, which was not controlled for in this study, rather than TBI history. In addition, the MMSE is only sensitive to substantial decreases in average cognitive functioning and cannot detect performance declines remaining in low average range, or higher, which may have related to concussion history in the current sample. However, the validity of the measures is supported by some expected findings in our sample - mental status was significantly negatively correlated with age and being male was significantly correlated with experiencing at least one TBI. Additionally, there was information that may have proved useful in this study but was not available through the HRS data, such as

the number of TBIs experienced. While there is reason to believe that number of TBIs experienced could increase influence on cognition, specifically memory and executive functioning (Belanger, Spiegel, & Vanderploeg, 2010), the number of TBIs experienced by a respondent was not identifiable in the dataset but could have produced interesting results.

For future research, a sample with a history of TBIs more severe than those in the current sample could yield more significant results. Previous research shows that those with more severe TBIs experience stronger deficits in cognition and domains such as social functioning (Janusez et al., 2002; Anderson et al., 2011). It would also be interesting to take into consideration number of TBIs and at what age the TBI, or TBIs, were experienced as the brain goes through different developmental stages throughout one's lifetime.

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