The Role of Psychological Flexibility in Recovery Following Mild Traumatic Brain Injury

Article *in* Rehabilitation Psychology · September 2021

DOI: 10.1037/rep0000406

5 authors, including:

Josh Faulkner
Victoria University of Wellington
20 PUBLICATIONS **95** CITATIONS

Alice Theadom
Auckland University of Technology
245 PUBLICATIONS **18,772** CITATIONS

Susan Mahon
Auckland University of Technology
24 PUBLICATIONS **414** CITATIONS

Suzanne Barker
University of Auckland
401 PUBLICATIONS **170,633** CITATIONS

Cite as: Faulkner, J. W., Snell, D. L., Theadom, A., Mahon, S., & Barker-Collo, S. (2021). The role of psychological flexibility in recovery following mild traumatic brain injury. *Rehabilitation Psychology*. Advance online publication. https://doi.org/10.1037/rep0000406

The role of psychological flexibility in recovery following mild traumatic brain injury

Josh W. Faulkner PhD[1], Deborah L. Snell PhD[2], Alice Theadom PhD[3], Susan Mahon PhD[3]

Suzanne Barker-Collo PhD[4]

[1] Massey University, PO Box 756, Wellington 6140, New Zealand

[2] University of Otago, Christchurch, 2 Riccarton Ave, Christchurch 8011

[3] TBI Network, Auckland University of Technology, University of Technology, 90 Akoranga Drive, Northcote, Auckland

[4] University of Auckland, Auckland CDB, Auckland 1010

[5] University of Otago, Wellington, 23A Mein Street, Newtown, Wellington, 6242

Correspondence to: Josh Faulkner, School of Psychology, College of Humanities and Social Sciences, Massey University, PO Box 756, Wellington

Email: j.faulkner1@massey.ac.nz

Phone: +64 4 801 5799 x 63601|

https://orcid.org/0000-0001-9555-4628

Abstract

Purpose and Objective: Psychological distress is known to contribute to recovery following mild traumatic brain injury (mTBI) and there is a need to understand the mechanisms that contribute to this relationship. The present study examined psychological flexibility, as a hypothesised psychological mechanism, in 169 treatment seeking adults with mTBI.

Research method/design: Participants completed self-report measures of post-concussion symptoms, psychological distress (anxiety, stress, and depression) and functional status within four weeks of entry to an mTBI outpatient clinic. A general measure (Acceptance and Action Questionnaire; AAQ-II), as well as a context specific (Acceptance and Action Questionnaire – Acquired Brain Injury; AAQ-ABI (RA)) measure of psychological flexibility were administered.

Results: Simple linear regression analysis showed that psychological flexibility made a significant contribution to the prediction of post-concussion symptoms and functional status. A series of multiple mediation analyses also found that psychological flexibility had a significant indirect effect on the relationships between psychological distress and post-concussion symptoms, and functional status. The context specific, rather than the general measure of psychological flexibility, was consistently shown to contribute to these findings.

Conclusions/Implications: These results suggest that psychological flexibility may be a psychological mechanism that contributes to recovery outcomes in individuals with mTBI and could therefore be an important treatment target in mTBI interventions.

Keywords: psychological flexibility, mild traumatic brain injury, post-concussion symptoms, outcomes

Impact and Implication Statement

- There is a growing need to identify the psychological mechanisms that explain the relationship between psychological factors and mild traumatic brain injury (mTBI) recovery outcomes; psychological flexibility may be one such mechanism.
- This study found that psychological flexibility significantly contributes to post-concussion symptoms and functional status in people after mTBI. Additionally, psychological flexibility partly mediated the relationship between psychological distress and post-concussion symptoms and functional status.
- The present study provides novel evidence that psychological flexibility may be an important psychological mechanism that contributes to recovery outcomes in individuals with mTBI.
- Psychological flexibility may be an important treatment target in mTBI interventions.

There has been a shift in the understanding of prognosis and long-term consequences of mild traumatic brain injury (mTBI) (Gardner & Yaffe, 2015). Historically, this injury was associated with limited and transient behavioural changes with only a small minority (termed the “miserable minority”) experiencing long term neuro-psychiatric sequelae (McCrea et al., 2003; Karr, Areshenkoff & Garcia-Barrera, 2014). However, recent evidence from large longitudinal cohort studies, where the confounds of selection bias are reduced, have found that nearly half of those with mTBI can experience persistent symptoms beyond the timeframes historically stipulated (Dikmen, Machamer, & Temkin, 2017; McInnes, Friesen, MacKenzie, Westwood, & Boe, 2017; McMahon et al., 2014; Theadom et al., 2016; Barker-Collo et al., 2013; Nelson et al., 2019). The impact of persistent post-concussion symptoms (PPCS) can be profound, causing significant disruptions in wellbeing, functioning and quality of life (McCrea, Iverson, McAllister, Hammeke, Powell, Barr, & Kelly, 2009; Silverberg, & Iverson, 2011; Carroll et al., 2014; Ahman, Saveman, Styrke, Bjornstig, & Stålnacke, 2013). It is therefore not surprising that mTBI is a significant and increasing public health problem globally (James et al., 2019; Te Ao et al., 2014). Consequently, understanding the factors that contribute to the development of PPCS is of importance.

There is strong evidence that psychological factors significantly impact recovery following mTBI (Broshek, De Marco & Freeman, 2015; Ponsford et al., 2012; 2019; Nelson et al., 2019; Barker-Collo et al., 2015; Scott et al., 2016). A pre-injury mental health condition, and acute psychological distress, have been found to be robust risk factors for PPCS (Silverberg et al., 2015), supporting biopsychosocial modelling of mTBI recovery outcomes. In short, these models highlight the role of pre-injury vulnerabilities, early physiological effects, and over time, an increasing role of psychosocial factors (Berrigan, Marshall, McCullagh,Velikonja, & Bayley, 2011; Krpan, Stuss, & Anderson, 2011; MacMillan, Hart, Martelli, & Zasler, 2002; McCrea et al., 2009; Polinder et al., 2018; Silverberg & Iverson, 2011; Iverson, 2019; Rickards, Cranston, & McWhorter, 2020; Young, 2020). Despite these proposed models, systematic reviews of prognostic factors and multivariable modelling have not yet identified a model that adequately predicts individual recovery outcomes from mTBI (Silverberg et al., 2015).

There have been recent attempts to identify the specific psychological mechanisms that influence the relationship between psychological factors and recovery outcomes after mTBI. Initial investigations suggest that fear avoidance, catastrophising, uncertainty, emotion habituation and self-efficacy may contribute to mTBI recovery (Wijenberg et al., 2017; Mantua & Ready, 2019; Yehene et al., 2019; Mah & Reed, 2018; Merz, Zane, Emmert, Lace, & Grant, 2019; Stubbs et al., 2020; Polich et al., 2019; Snell et al., 2015; Greenberg et al., 2020; Silverberg et al., 2017). Yet, systematic reviews have found limited evidence supporting psychological interventions which would target these factors (e.g. Cognitive Behavioural Therapy) for the management of post-concussion symptoms (Snell, Surgenor, Hay-Smith & Siegert, 2009; Sullivan et al., 2020; Arbabi, Sheldon, Bahadoran, Smith, Poole, & Agrawal, 2020; Teo, Fong, Chen, & Chung, 2020). Methodological problems with included studies aside, one possibility is that these types of interventions may not sufficiently address underlying psychological mechanisms. Consequently, identifying additional psychological mechanisms that contribute to symptom persistence could also inform psychological treatments and result in more efficacious recovery outcomes after mTBI.

Psychological flexibility may be one such mechanism that contributes to recovery outcomes after mTBI (Whiting et al. 2015; Whiting et al., 2017 Faulkner et al., 2020). Psychological flexibility can be succinctly defined as the pursuit of values despite the presence of pain or distress (Kashdan, Disabato, Goodman, Doorley & McKnight, 2020; Hayes et al., 2004; Hayes, Strosahl, & Wilson, 2011). More specifically, psychological flexibility involves adapting to changing situational demands, allocating mental resources, shifting perspective, and finding balance amongst competing demands (Kashdan & Rottenberg, 2010). Psychologically flexible individuals are less invested in controlling uncomfortable internal states with the sole aim to maximise pleasant and minimise unpleasant feelings (Kashdan et al., 2020). Psychological inflexibility contributes to a range of health conditions including, depression, anxiety, eating disorders, chronic pain and insomnia (Bond et al., 2011; Masuda & Tully, 2012; Chawla & Ostafin, 2007; Leonidou, Panayiotou, Bati, & Karekla, 2019; Bohlmeijer, Fledderus, Rokx, & Pieterse, 2011; Scott, Hann, & McCracken, 2016; Luoma, Drake, Kohlenberg, & Hayes, 2011; Bluett et al., 2016; de Boer, Steinhagen, Versteegen, Struys &

Sanderman, 2014; Densham, Williams, Johnson, & Turner-Cobb, 2016). Psychological flexibility is conceptualised as a psychological mechanism as it exerts an influence on the relationship between psychological factors (i.e. rumination, impulsivity) and health outcomes (i.e. psychological distress, pain, fatigue) (Morris & Mansell, 2018). That is, high levels of psychological inflexibility can result in the rigid implementation of these factors which maintains psychological symptoms. Psychological flexibility is a viable target for psychological interventions, lying at the core of Acceptance and Commitment therapy (ACT; Hayes, Strosahl & Wilson, 2009). Psychological flexibility has been found to mediate mental health outcomes in several ACT randomised controlled trials (Arch, Wolitzky-Taylor, Eifert, & Craske, 2012; Forman et al., 2012; Twohig, Plumb Vilardaga, Levin, & Hayes, 2015).

Psychological flexibility has been found to be context specific; that is, inflexible responses can manifest specifically in response to thoughts and feelings that pertain to a specific condition (Ong, Lee, Levin & Twohig, 2019). As a result, alongside general measures of psychological flexibility (i.e. the Action and Acceptance Questionnaire Revised (AAQ-II; Bond et al., 2011), researchers have derived domain specific variants that assess psychological flexibility in particular conditions, for example body image concerns (Body Image Acceptance and Action Questionnaire [BI-AAQ] (Sandoz, Wilson, Merwin & Kellum, 2013)). Due to more specific wording, these measures can provide a more sensitive measure of psychological flexibility with respect to the problem of interest (Gregg et al., 2007; Houghton et al., 2014; Vowles & McCracken, 2008). In a review of AAQ-II and its variants, Ong et al., (2019) found that context specific measures performed better than a generic measure of psychological flexibility with respect to incremental validity and sensitivity to treatment effects. In the broader Acquired Brain Injury (ABI) context, Whiting and colleagues (2015) explored the impact of psychological flexibility on mental health outcomes. In this study, the AAQ-II, as well as a context specific derivative (AAQ-ABI) were administered. They found that in 150 participants with ABI (117 severe traumatic brain injury, 11 brain tumour, 9 hypoxic injury, 13 cerebrovascular accident), self-report measures of reduced psychological flexibility were significantly associated with increased depression, anxiety and stress. The authors noted that the magnitude of the correlation differed between the AAQ-II and the AAQ-ABI suggesting that both measures may be capturing different aspects of psychological flexibility. In support of the use of context specific variants of psychological flexibility, it was concluded that the AAQ-ABI appears to measure psychological flexibility about the thoughts and feeling related to a brain injury, whereas the AAQ-II measures psychological flexibility about general psychological distress.

Recently, Faulkner and colleagues (2020) proposed that psychological flexibility is a mechanism that might influence recovery outcomes following mTBI. This hypothesis was based on the following: a relationship exists between psychological flexibility and pre-injury psychological risk factors such as a pre-injury mental health condition (Meares et al., 2008; Silverberg et al., 2015) and resilience (Sullivan, Kempe, Edmed & Bonanno (2016); psychological flexibility may be associated with frontal lobe functioning (Whiting et al., 2017), brain regions known to be vulnerable to the pathophysiology associated with mTBI (Lipton et al., 2015). Further, following the injury, post-concussion symptoms such as low mood, stress and anxiety, and neuropsychological dysfunction, such as executive function difficulties, may be present (Ruff et al., 2009). These factors are all associated with psychological inflexibility (Whiting et al., 2017; Kashdan & Rottenberg, 2010). Although a lack of evidence exists at present, post-concussion symptoms may exacerbate and maintain the effects of pre-injury risk and/or the injury-related impacts on psychological flexibility. Finally, post-concussion symptoms following mTBI can also precipitate certain psychological responses, such as avoidance, to cope with the ongoing effects of the injury. Psychological inflexibility could result in these responses being applied more rigidly and thus contribute to symptom persistence and reduced functioning (Morris & Mansell, 2018). The objective of this study is to begin to test this hypothesis and examine the role of psychological flexibility in mTBI recovery. To achieve this, we first aim to investigate if psychological flexibility makes a unique contribution to post-concussion symptoms and functional status. We also aim to examine psychological flexibility as a psychological mechanism and explore its role in influencing the relationship between psychological distress and mTBI recovery outcomes.

Method

Participants and Procedure

The Auckland University of Technology ethics committee provided ethics approval for this study (ref 20/32). Adult patients were recruited from outpatient clinics providing rehabilitation services for mTBI in the North Island of New Zealand between March 2020 and September 2020. At the recruitment sites, participants were approached by a clinician within one month of entry into the service and invited to participate. Inclusion criteria were adults 18 years or older who had been diagnosed with an mTBI in accordance with the WHO Neurotrauma Taskforce criteria (Holm et al., 2005). Patients that were non-fluent in English, had a prior neurological condition, or had a severe unstable medical condition were excluded. Eligible and consenting participants completed questionnaires via REDCap (Harris, Taylor, Thielke, Payne, Gonzalez, & Conde, 2009), a secure web-based platform, or via telephone (with data entered into the database manually).

Measures

Demographic and Clinical Variables: Data on demographic and clinical variables were ascertained via the online self-report questionnaire. Demographic variables included: age, gender, ethnicity, education, relationship status, pre-injury employment status, as well as medical, concussion and mental health history. Clinical variables were time since injury, mechanism of injury, and other injury sustained.

Psychological Flexibility. *Acceptance and Action Questionnaire (AAQ-II)*. The AAQ-II measures experiential avoidance (EA), which is thought to be indicative of psychological *in*flexibility. EA involves both emotional and behavioural avoidance employed to minimise the discomfort associated with internal experiences (Hayes, Wilson, Gifford, Follette, & Strosahl. 1996). It is a manifestation of psychological inflexibility because engaging in EA leads one to respond in an inconsistent or inflexible manner to a variety of experiences. The AAQ-II is a 7-item questionnaire utilising a 7-point Likert scale (response format, 1 = ‘never true’ to 7 = ‘always true’) with scores ranging from 7 to 49. Higher scores are indicative of greater psychological inflexibility or experimental avoidance. The

AAQ-II has been found to have good reliability and validity, with the Confirmatory Factor Analysis of this measure supporting a one-factor model (Cronbach's alpha ranging from 0.78 to 0.88; Bond et al., 2011).

AAQ-ABI (RA). The AAQ-ABI (Reactive Avoidance (RA)) is a 9-item questionnaire containing questions to address experiential avoidance associated with reactions about having a brain injury (Sylvester, 2011; Whiting et al., 2015). The reactive avoidance subscale is derived from the 15 item, AAQ-ABI (Sylvester, 2011). The AAQ-ABI has a three factor structure (factor 1 (9 items) = reactive avoidance; factor 2 (2 items) = denial; factor 3 (2 items) = active acceptance), however, factors 2 and 3 have been found to have poor psychometric properties (Whiting et al., 2015). As a result, in the present study only the AAQ-ABI (RA) was used. The AAQ-ABI (RA) uses a 5-point Likert scale (0= 'never true' to 4 = 'always true') with scores ranging from 0 to 36; higher scores indicate greater psychological inflexibility associated with an ABI. The measure has been developed and validated in an undifferentiated sample of ABI (Cronbach's alpha 0.89; Whiting et al., 2015). In the current study, items within the questionnaire were modified by replacing "brain injury" with "concussion" in accordance with the characteristics of the sample and their engagement in an outpatient treatment programme that was referred to as a 'concussion service'. Faulkner and colleagues (2021) found that the AAQ-ABI (RA) has one distinct underlying factor in an mTBI sample and strong internal consistency (Cronbach's $\alpha = 0.87$). In accordance with their recommendations, in the current study, ordinal measures were converted to interval scores using their conversion table to improve the psychometric properties of the measure.

Post-Concussion Symptoms. The Rivermead Post-Concussion Symptom Questionnaire (RPQ) is a 16 item self-report questionnaire that assesses common symptoms following mTBI (Cronbach's alpha = 0.90) (King, Crawford, Wenden, Moss & Wade, 1995). The RPQ consists of somatic symptoms (headaches, dizziness, nausea and vomiting, noise and light sensitivity, sleep disturbance and double vision); cognitive symptoms (forgetfulness/poor memory, poor concentration, and taking longer to think); and emotional symptoms (being irritable/easily angered feeling depressed or tearful, feeling frustrated or impatient). Participants are required to rate the presence and problem status of these symptoms on a scale of 0 - 4 (0 = not experienced at all; 1 = no more of a problem than before injury; 2 = a mild problem; 3 = a moderate problem; 4 = a severe problem). Scores of 1 ("no more of a problem than before injury") were recoded to 0 as per the recommendations of King et al., (1995).

Psychological Distress. The Depression, Anxiety and Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995) is a 21 item self-report with three subscales that measure depression, anxiety, and stress over the previous week. It utilises a 4-point Likert scale with 0 = never, 1 = sometimes, 2 = often, and 3 = always. Higher scores on this measure are indicative of elevated levels of depression, anxiety and stress. The DASS-21 has good psychometric properties (Cronbach's alpha = 0.73-0.81; Lovibond & Lovibond, 1995) and is a valid measure of depression, anxiety and stress in people with ABI (Ownsworth, Little, Turner, Hawkes, & Shum, 2008). A recent structural equation modeling analysis supported a three-factor structure of the DASS-21, and the internal consistency of each factor was very good (Cronbach's alpha = 0.82-0.90, Randall, Thomas, Whiting, & McGrath, 2017).

Functional Status. The 12-item WHO Disability Assessment Schedule (WHODAS 2.0) is a questionnaire evaluating disability representing six International Classification of Functioning (ICF) activity and participation domains including cognition, self-care, mobility, interpersonal functioning, life activities, and participation (Üstün, Kostanjsek, Chatterji & Rehm, 2010; Federici, Bracalenti, Meloni & Luciano, 2016). The WHODAS 2.0 asks respondents how much difficulty they have had in the past 30 days in relation to all their health problems for each of the 12 items. The Likert scale options are: 0 = none, 1 = mild, 2 = moderate, 3 = severe, and 4 = extreme/cannot do (higher scores represent greater disability). Snell, Siegert and Silverberg (2020) showed that the 12-item WHODAS 2.0 had high internal consistency in mTBI (Cronbach's alpha = 0.92). In accordance with their recommendations, in the current study, ordinal scores on the WHODAS 2.0 were converted to interval scores using their conversion table provided, to improve the psychometric properties of the measure.

Data Analysis. Statistical analyses were computed using SPSS version 26. The dataset was complete (no missing data), and so no imputation strategies were required. Statistical significance was set to $p<0.05$. A power analysis using the G*power software (Faul et al., 2009) was used to ensure adequate same size for the regression and mediation analyses. Assuming a medium effect size (f^2) of 0.15, an alpha of 0.80, and a maximum of 11 predictors, power analysis suggested a minimum sample of 123 participants. Descriptive analyses and Pearson's product moment correlations (r) (Field, 2013) were conducted to broadly characterize psychological flexibility and demographic, clinical, and questionnaire measures in our sample. In accordance with our first aim, which is to determine the unique contribution of psychological flexibility to post-concussion symptoms and functional status, regression analyses were run. Both the context specific (AAQ-ABI (RA)) and general measure of psychological flexibility (AAQ-II) were entered into the model based on previous findings that these measures capture different aspects of psychological flexibility (Whiting et al., 2017). To control for possible confounding effects, demographic and clinical variables known to exert an influence on outcomes (post-concussion symptoms/functional status) and/or psychological flexibility were selected (Heinze, Wallisch & Dunkler, 2018). This included age (Karr, Luoto, Gilman, Berghem, Kotilainen & Iverson, 2020), gender (Bazarian, Blyth, Mookerjee, He, & McDermott, 2010), other injury sustained (Cnossen et al., 2018), medical history (Ponsford et al., 2012), concussion history (Theadom et al., 2016), and mental health history (Silverberg et al., 2015). Additionally, given the association between psychological flexibility and psychological distress (Whiting et al., 2017; Leahy & Melwani, 2012), measures of anxiety, depression and stress were included in the model, to ensure the unique role of psychological flexibility could be captured. The selected predictor variables were entered into a multiple regression model to identify the factors that made a significant ($p<0.05$) contribution to either RPQ and WHODAS 2.0.

To achieve our second aim mediation analysis was used, given the role of psychological flexibility as a mechanism that exerts an influence on the relationship between two variables (psychological factors and recovery outcomes) (MacKinnon, Fairchild & Fritz, 2010). A series of mediation analyses were conducted using PROCESS for SPSS (Hayes, 2012) to evaluate the indirect effects of psychological flexibility for the relationship between predictors (anxiety, depression and stress) and dependent variables (post-concussion symptoms and functional status). Multiple mediation analyses were conducted for the two measures of psychological flexibility (M_1 = AAQ-ABI (RA) and

M_2 = AAQ-II). We estimated the individual effect of each dependent variable on each mediator (i.e. stress, AAQ-ABI(RA); path A), the effect of each mediator on the predictor variables (i.e. AAQ-ABI(RA), post-concussion symptoms; path B), and the indirect effect of the dependent variables through each of the individual mediators (path A x B). We compared the direct effect (path C'; the effect of the dependent variable on the predictor variable minus each mediator) and the total effect (path C; the effect of the dependent variable on the predictor variable plus each mediator). We assessed the magnitude of all mediation effects (paths A x B) by the standardized beta coefficients. Six models were analysed, with each predictor and dependent variable, and two mediators (PROCESS model #4). We assessed the reliability of the sample mediation effects via the percentile (nonparametric) 95% confidence interval (CI) generated by a bootstrapping procedure with a resample rate of 5,000 to avoid inflation of type 1 error rate (Preacher & Hayes, 2008; Fritz, Taylor & MacKinnon, 2012). Bootstrapping is a computational nonparametric resampling technique that enables population characteristics to be estimated from the existing sample (Mooney & Duval, 2006). We report variance in post-concussion symptoms and functional status that is explained by each mediation model (overall R^2).

Results

The sample consisted of 169 adults with mTBI. Table 1 presents the demographic and injury characteristics of the sample.

--Table 1--

Mean, standard deviations, and range for all self-report measures are reported in Table 2. The sample had on average anxiety, depression, and stress scores in the mild range.

--Table 2--

Contribution of Psychological Flexibility to Post-Concussion Symptoms and Functional Status

As shown in Table 3, psychological flexibility was a significant predictor of post-concussion symptoms and functional status. Specifically, the context specific measure of psychological flexibility

(AAQ-ABI (RA)) made a significant contribution to post-concussion symptoms ($\beta = 1.06$, $p<.001$), and functional status ($\beta = -0.48$, $p<.001$), whilst accounting for demographic, clinical and psychological variables. In addition to psychological flexibility, medical history ($\beta =-3.70$, $p<.001$), and stress ($\beta =1.33$, $p<.001$), also significantly contributed to post-concussion symptoms. Anxiety ($\beta = 0.19$, $p<.001$) also made a significant contribution to functional status.

---Table 3---

The mediation effects of psychological flexibility in the relationship between psychological distress and outcomes

The bootstrapped method (PROCESS) with n = 5000 bootstrap resamples and 95% bias corrected and accelerated confidence intervals was used in a series of analyses to examine the indirect effects of psychological flexibility (M_1 = AAQ-ABI (RA), M_2 = AAQ-II) on the relationship between psychological distress (stress, anxiety, depression) and outcomes (post-concussion symptoms and functional status).

All six multiple indirect effect models, with post-concussion symptoms and functional status (x) as predictors and anxiety, stress, and depression (y) as dependent variables, showed a significant indirect effect of psychological flexibility (i.e. the combined indirect effects of AAQ-ABI (RA) and AAQ-II). Detailed results of each model pertaining to each dependent variable showing the indirect effects are summarised in Table 4

---Table 4---

Stress, Psychological Flexibility and Outcomes

The full model showed a significant indirect effect of psychological flexibility on the relationship between stress and post-concussion symptoms ($\beta = .35$, $p<.01$), and stress and functional status ($\beta = .32$, $p<.01$). Among the individual psychological flexibility factors, in both models, only the AAQ-ABI (RA) had a significant indirect effect in the full model (path A X B; post-concussion symptoms: $\beta = 0.44$, $p <.01$; functional status: $\beta = 0.26$, 95% $p<.01$). In each analysis, on each respective path, the AAQ-ABI (RA) illustrated significant coefficients in both a and b paths. The

AAQ-ABI (RA) showed significant coefficients in both paths when functional status was the predictor variable (see Figure 1). The total effects of stress on post-concussion symptoms and functional status was significant ($\beta = 1.75$, $P < .01$; $\beta = .54$, $P < .01$), as was the direct effect of stress on post-concussion symptoms and functional status ($\beta = 1.40$, $P < .01$; $\beta = .18$, $P < .01$), indicating that the mediation was partial. The model explained 49.76% of the variance on post-concussion symptoms and 47.38% on functional status.

---Figure 1--

Anxiety, Psychological Flexibility and Outcomes

The full model showed a significant indirect effect of psychological flexibility on the relationship between anxiety and post-concussion symptoms ($\beta = .65$, $p < .01$), and anxiety and functional status ($\beta = .32$, $p < .01$). Among the individual psychological flexibility factors, in both models, only the AAQ-ABI (RA) had a significant indirect effect in the full model (path A X B; post-concussion symptoms: $\beta = 0.63$, $p < .01$; functional status: $\beta = 0.24$, 95% $p < .01$). In each analysis, on each respective path, the AAQ-ABI illustrated significant coefficients in both a and b paths (see Figure 2). The total effects of anxiety on post-concussion symptoms and functional status was significant ($\beta = 1.52$, $P < .01$; $\beta = .59$, $p < .01$), as was the direct effect of stress on post-concussion symptoms and functional status ($\beta = 0.88$, $P < .01$; $\beta = .26$, $p < .01$), indicating that the mediation was partial. The full model explained 40.86% of the variance on post-concussion symptoms and 49.23% on functional status.

---Figure 2--

Depression, Psychological Flexibility and Outcomes

The full model showed a significant indirect effect of psychological flexibility on the relationship between depression and post-concussion symptoms ($\beta = .63$, $P < .01$), and depression and functional status ($\beta = .31$, $p < .01$). Among the individual psychological flexibility factors, in both models, only the AAQ-ABI (RA) had a significant indirect effect in the full model (path A X B; post-concussion symptoms: $\beta = 0.62$, $p < .01$; functional status: $\beta = 0.23$, $p < .01$). In each analysis, on each respective path, the AAQ-ABI(RA) illustrated significant coefficients in both a and b paths (see

Figure 3). The total effects of depression on post-concussion symptoms and functional status was significant ($\beta = 1.11$, $P < .01$; $\beta = .46$, $p < .01$), as was the direct effect of stress on post-concussion symptoms and functional status ($\beta = 0.49$, $P < .01$; $\beta = .15$, $p < .01$), indicating that the mediation was partial. The full model explained 37.10% of the variance on post-concussion symptoms and 46.81% on functional status.

---Figure 3---

Discussion

The objective of this study was to examine the role of psychological flexibility in recovery after mTBI. To achieve this, we aimed to examine the unique contribution of psychological flexibility on mTBI recovery outcomes. After considering demographic and clinical variables, as well as current mental health status, psychological flexibility was found to significantly contribute to post-concussion symptoms and functional status. A further aim of this study was to examine psychological flexibility as a psychological mechanism that mediates the relationship between psychological distress and recovery outcomes after mTBI. A series of simple mediation analyses found that psychological flexibility partially mediated the relationship between psychological distress and recovery outcomes. Specifically, the multiple mediation model and bootstrapping procedure indicated that psychological flexibility meaningfully contributed to the relationship between stress, anxiety and depression, on post-concussion symptoms and functional status. With psychological flexibility as a mediating variable, in some of the analyses nearly half of the variance on post-concussion symptoms and functional status was explained; with slightly better prediction with anxiety and stress as the starting point of the model as compared to depression.

The results of this study support previous research highlighting the role of psychological flexibility in health conditions. Psychological flexibility has been found to have a significant effect on symptoms in those with chronic pain, insomnia, fibromyalgia and chronic fatigue (Wicksell et al., 2013; de Boer et al., 2014; Densham, Williams, Johnson, & Turner-Cobb, 2016; McCracken, & Morley, 2014; McCracken, Williams, & Tang 2011). For example, Gentili and colleagues (2019) found that psychological flexibility (measured as avoidance, value obstruction, and value progress) had a significant indirect effect on the relationship between symptoms and functioning in chronic pain. Most pertinent to the current study, psychological flexibility has been found to contribute to mental health outcomes in ABI (Whiting et al., 2015), and holds promise as an important change mechanism in psychological interventions in this population (Whiting et al., 2020; 2020; Sander et al., 2020). The current results provide preliminary evidence that psychological flexibility may contribute to post-concussion symptoms and functional status after mTBI. Further evidence is needed, however, interventions that target psychological flexibility may improve recovery outcomes after mTBI.

Psychological flexibility is context specific and as a result measures have been designed to assess this construct in particular conditions (Ong, Lee, Levin, & Twohig, 2019). In the current study. two measures of psychological flexibility; a general measure (the AAQ-II), as well as a context specific derivative (AAQ-ABI (RA)) were used. Our results support findings that context specific measures are more sensitive at detecting psychological flexibility in the domain of interest (Gregg et al., 2007, Houghton et al., 2014, Vowles & McCracken, 2008). This study found that only the context specific measure (AAQ-ABI (RA)) contributed significantly to recovery outcomes, and partially mediated the relationship between psychological distress, post-concussion symptoms, and functional status. Although further research is needed, these findings could inform the treatment approaches utilised for mTBI population. It suggests that when targeting psychological flexibility in people with mTBI, intervention techniques, such as those proposed by ACT (i.e. mindfulness, acceptance, defusion), could be tailored to address thoughts and feelings specifically pertaining to the mTBI.

Psychological difficulties are common among people after mTBI and can be precipitated by the injury (van der Horn et al., 2019), it's impact on functioning (Broshek, De Marco, & Freeman, 2015) and psychosocial stressors (Bryant, 2008). It may also reflect a continuation and exacerbation of pre-injury mental health status (Karr et al., 2019). Psychological factors have a significant role in predicting recovery following mTBI (Silverberg et al., 2015). Attempts are now being made to understand the psychological mechanisms that underlie this relationship (Silverberg et al., 2018). This will improve explanatory models and provide targets for mTBI interventions. Our results suggest that psychological flexibility may be one such mechanism. Fear avoidance has also been proposed as a mechanism that could contribute to mTBI recovery (Cassetta, Cairncross, Brasher, Panenka, & Silverberg, 2020; Silverberg, Panenka, & Iverson, 2018; Wijenberg et al., 2017). Fear avoidance postulates that anxiety may lead to symptom amplification due to misattribution of symptoms and elimination or reduction of activities. Interestingly, getting stuck in misattributing patterns (i.e. catastrophising) or avoidant behaviour could be conceptualised as a manifestation of psychological inflexibility (Özkan, Zale, Ring, & Vranceanu, 2017). Future research would benefit from exploring these associations as psychological flexibility may also influence recovery after mTBI through other mediating mechanisms such as fear avoidance and catastrophising.

There are limitations that need to be considered when interpreting the results of the study. We used a cross-sectional design and as such causality cannot be inferred. The relationships between examined variables in the mediation models are likely to be bidirectional, with post-concussion symptoms and reduced functional status increasing psychological distress through the mediating role of psychological flexibility. Future research should explore these relationships within longitudinal designs to examine how these relationships might evolve or change over time. This is particularly pertinent for mTBI in which the development of PPCS can transpire with time. Our sample were recruited within one month of entry to an outpatient mTBI treatment service and the average time since injury (8.73 weeks) was below current definitions of persistent symptoms (typically greater than three months). Future research should aim to explore psychological flexibility over multiple time points to investigate its role in the development and maintenance of persistent symptoms. It is also important to highlight that participants had been referred for specialty care for the management of their post-concussion symptoms, and therefore our sample is not representative of the wider mTBI population. The study findings there cannot be generalised to the wider mTBI population. Finally, the AAQ-II, and therefore the AAQ-ABI, measures one facet of psychological flexibility, reactive avoidance. Future research would benefit from exploring the relationship between psychological flexibility and mTBI recovery outcomes using more comprehensive measures of psychological flexibility such as the Multidimensional Psychological Flexibility Index (Rolffs, Rogge, & Wilson, 2018) or the Personalised Psychological Flexibility Index (PPFI; Kashdan et al., 2020).

Conclusion

In this study, psychological flexibility significantly contributed to post concussion symptoms and functional status in a sample of treatment seeking adults with mTBI. In addition, psychological flexibility had a significant mediating role on the relationship between psychological distress and outcomes (post-concussion symptoms and functional status). The present findings suggest that psychological flexibility may be an important psychological mechanism that could contributes to mTBI recovery and may be an important treatment target in mTBI interventions.

References

1. Ahman, S., Saveman, B. I., Styrke, J., Bjornstig, U., & Stålnacke, B. M. (2013). Long-term follow-up of patients with mild traumatic brain injury: a mixed-method study. *Journal of rehabilitation medicine*, *45*(8), 758-764.
2. Arbabi, M., Sheldon, R. J. G., Bahadoran, P., Smith, J. G., Poole, N., & Agrawal, N. (2020). Treatment outcomes in mild traumatic brain injury: a systematic review of randomized controlled trials. *Brain injury*, *34*(9), 1139-1149.
3. Arch, J. J., Wolitzky-Taylor, K. B., Eifert, G. H., & Craske, M. G. (2012). Longitudinal treatment mediation of traditional cognitive behavioral therapy and acceptance and commitment therapy for anxiety disorders. *Behaviour research and therapy*, *50*(7-8), 469-478.
4. Barker-Collo, S., Theadom, A., & Feigin, V. (2015). Prevalence, natural course, and predictors of depression one year following traumatic brain injury from a population–based study in New Zealand. Brain Injury, 29(7-8):859-865. doi: 10.3109/02699052.2015.1004759
5. Barker-Collo, S., Theadom, A., Ameratunga, S., Jones, K., Jones, A., Starkey, N., & Feigin, V. on behalf of the BIONIC Research Group.(2013). Prevalence and predictors of post-traumatic stress disorder in adults one year following traumatic brain injury: A population-based study. Brain Impairment,14(3), 425-435. doi: 10.1017/BrImp.2013.27.
6. Bazarian, J. J., Blyth, B., Mookerjee, S., He, H., & McDermott, M. P. (2010). Sex differences in outcome after mild traumatic brain injury. *Journal of neurotrauma*, *27*(3), 527-539
7. Berrigan, L., Marshall, S., McCullagh, S., Velikonja, D., & Bayley, M. (2011). Quality of clinical practice guidelines for persons who have sustained mild traumatic brain injury. *Brain Injury*, *25*(7-8), 742-751. https://doi.org/10.3109/02699052.2011.580317
8. Bluett, E. J., Lee, E. B., Simone, M., Lockhart, G., Twohig, M. P., Lensegrav-Benson, T., & Quakenbush-Roberts, B. (2016). The role of body image psychological flexibility on the treatment of eating disorders in a residential facility. Eating Be- haviors, 23, 150–155
9. Bohlmeijer, E. T., Fledderus, M., Rokx, T. A. J. J., & Pieterse, M. E. (2011). Efficacy of an early intervention based on acceptance and commitment therapy for adults with depressive symptomatology: Evaluation in a randomized controlled trial. *Behaviour research and therapy*, *49*(1), 62-67. https://doi.org/10.1016/j.brat.2010.10.003
10. Bond, F. W., Hayes, S. C., Baer, R. A., Carpenter, K. M., Guenole, N., Orcutt, H. K., ... & Zettle, R. D. (2011). Preliminary psychometric properties of the Acceptance and Action Questionnaire–II: A revised measure of psychological inflexibility and experiential avoidance. *Behavior therapy*, *42*(4), 676-688. https://doi.org/10.1016/j.beth.2011.03.007
11. Broshek, D. K., De Marco, A. P., & Freeman, J. R. (2015). A review of post-concussion syndrome and psychological factors associated with concussion. *Brain injury*, *29*(2), 228-237.

12. Bryant, R. A. (2008). Disentangling mild traumatic brain injury and stress reactions. *New England Journal of Medicine*, *358*(5), 525.
13. Carroll, L. J., Cassidy, J. D., Cancelliere, C., Côté, P., Hincapié, C. A., Kristman, V. L., ... & Hartvigsen, J. (2014). Systematic review of the prognosis after mild traumatic brain injury in adults: cognitive, psychiatric, and mortality outcomes: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Archives of physical medicine and rehabilitation*, *95*(3), S152-S173.
14. Cassetta, B. D., Cairncross, M., Brasher, P., Panenka, W. J., & Silverberg, N. D. (2020). Avoidance and endurance coping after mild traumatic brain injury are associated with disability outcomes. *Rehabilitation psychology*.
15. Chawla, N., & Ostafin, B. (2007). Experiential avoidance as a functional dimensional approach to psychopathology: An empirical review. *Journal of clinical psychology*, *63*(9), 871-890. https://doi.org/10.1002/jclp.20400
16. Cnossen, M. C., van der Naalt, J., Spikman, J. M., Nieboer, D., Yue, J. K., Winkler, E. A., ... & Lingsma, H. F. (2018). Prediction of persistent post-concussion symptoms after mild traumatic brain injury. *Journal of neurotrauma*, *35*(22), 2691-2698.
17. de Boer, M. J., Steinhagen, H. E., Versteegen, G. J., Struys, M. M., & Sanderman, R. (2014). Mindfulness, acceptance and catastrophizing in chronic pain. *PloS one*, *9*(1), e87445.
18. Densham, S., Williams, D., Johnson, A., & Turner-Cobb, J. M. (2016). Enhanced psychological flexibility and improved quality of life in chronic fatigue syndrome/myalgic encephalomyelitis. *Journal of psychosomatic research*, *88*, 42-47.
19. Dikmen, S., Machamer, J., & Temkin, N. (2017). Mild traumatic brain injury: longitudinal study of cognition, functional status, and post-traumatic symptoms. *Journal of neurotrauma*, *34*(8), 1524-1530. https://doi.org/10.1089/neu.2016.4618
20. Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior research methods*, *41*(4), 1149-1160.
21. Faulkner, J. W., Theadom, A., Mahon, S., Snell, D. L., Barker-Collo, S., & Cunningham, K. (2020). Psychological flexibility: A psychological mechanism that contributes to persistent symptoms following mild traumatic brain injury?. *Medical hypotheses*, *143*, 110141.
22. Faulkner, J.W, Snell, D. L., Theadom, A., Mahon, S., Barker-Collo, S., & Skirrow, P (2021). *Psychological flexibility in Mild Traumatic Brain Injury: An Evaluation of Measures*. Manuscript submitted for publication.
23. Federici, S., Bracalenti, M., Meloni, F., & Luciano, J. V. (2017). World Health Organization disability assessment schedule 2.0: An international systematic review. *Disability and rehabilitation*, *39*(23), 2347-2380.
24. Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. sage.

25. Forman, E. M., Chapman, J. E., Herbert, J. D., Goetter, E. M., Yuen, E. K., & Moitra, E. (2012). Using session-by-session measurement to compare mechanisms of action for acceptance and commitment therapy and cognitive therapy. *Behavior therapy*, *43*(2), 341-354.
26. Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological science*, *18*(3), 233-239.
27. Fritz, M. S., Taylor, A. B., & MacKinnon, D. P. (2012). Explanation of two anomalous results in statistical mediation analysis. *Multivariate Behav Res*, *47*(1), 61–87. 10.1080/00273171.2012.640596
28. Gardner, R. C., & Yaffe, K. (2015). Epidemiology of mild traumatic brain injury and neurodegenerative disease. *Molecular and Cellular Neuroscience*, *66*, 75-80.
29. Gentili, C., Rickardsson, J., Zetterqvist, V., Simons, L., Lekander, M., & Wicksell, R. K. (2019). Psychological flexibility as a resilience factor in individuals with chronic pain. *Frontiers in psychology*, *10*, 2016.
30. Greenberg, J., Mace, R. A., Funes, C. J., Silverberg, N. D., Iverson, G. L., Caplan, D. N., & Vranceanu, A. M. (2020). Pain Catastrophizing and Limiting Behavior Mediate the Association Between Anxiety and Postconcussion Symptoms. *Psychosomatics*, *61*(1), 49-55. https://doi.org/10.1016/j.psym.2019.09.004
31. Gregg, J. A., Callaghan, G. M., Hayes, S. C., & Glenn-Lawson, J. L. (2007). Improving diabetes self-management through acceptance, mindfulness, and values: a randomized controlled trial. *Journal of consulting and clinical psychology*, *75*(2), 336.
32. Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics*, *42*(2), 377-381.
33. Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling.
34. Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (2009). *Acceptance and commitment therapy*. Washington, DC:: American Psychological Association.
35. Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (2011). Acceptance and commitment therapy: The process and practice of mindful change (2nd ed.). New York, NY: Guilford Press
36. Hayes, S. C., Strosahl, K., Wilson, K. G., Bissett, R. T., Pistorello, J., Toarmino, D., ... & Stewart, S. H. (2004). Measuring experiential avoidance: A preliminary test of a working model. *The psychological record*, *54*(4), 553-578.
37. Hayes, S. C., Wilson, K. G., Gifford, E. V., Follette, V. M., & Strosahl, K. (1996). Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of consulting and clinical psychology*, *64*(6), 1152.

38. Houghton, D. C., Compton, S. N., Twohig, M. P., Saunders, S. M., Franklin, M. E., Neal-Barnett, A. M., ... & Woods, D. W. (2014). Measuring the role of psychological inflexibility in trichotillomania. *Psychiatry research*, *220*(1-2), 356-361.
39. Iverson, G. L. (2019). Network analysis and precision rehabilitation for the post-concussion syndrome. *Frontiers in neurology*, *10*, 489.
40. James, S. L., Theadom, A., Ellenbogen, R. G., Bannick, M. S., Montjoy-Venning, W., Lucchesi, L. R., ... & Afarideh, M. (2019). Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet Neurology, 18(1), 56-87 https://doi.org/10.1016/S1474-4422(18)30415-0
41. Karr, J. E., Iverson, G. L., Huang, S. J., Silverberg, N. D., & Yang, C. C. (2019). Perceived change in physical, cognitive, and emotional symptoms after mild traumatic brain injury in patients endorsing pre-injury anxiety or depression. *Journal of Neurotrauma*.
42. Karr, J. E., Luoto, T. M., Gilman, I. G., Berghem, K., Kotilainen, A. K., & Iverson, G. L. (2020). Age, symptoms, and functional outcome after mild traumatic brain injury. *Acta Neurologica Scandinavica*, *141*(2), 183-190.
43. Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical psychology review*, *30*(7), 865-878. https://doi.org/10.1016/j.cpr.2010.03.001
44. Kashdan, T. B., Disabato, D. J., Goodman, F. R., Doorley, J. D., & McKnight, P. E. (2020). Understanding psychological flexibility: A multimethod exploration of pursuing valued goals despite the presence of distress. *Psychological Assessment*, *32*(9), 829.
45. King, N. S., Crawford, S., Wenden, F. J., Moss, N. E. G., & Wade, D. T. (1995). The Rivermead Post Concussion Symptoms Questionnaire: a measure of symptoms commonly experienced after head injury and its reliability. *Journal of neurology*, *242*(9), 587-592.
46. Krpan, K. M., Stuss, D. T., & Anderson, N. D. (2011). Coping behaviour following traumatic brain injury: What makes a planner plan and an avoider avoid?. *Brain injury*, *25*(10), 989-996. https://doi.org/10.3109/02699052.2011.597045
47. Lipton, M. L., Gulko, E., Zimmerman, M. E., Friedman, B. W., Kim, M., Gellella, E., ... & Branch, C. A. (2009). Diffusion-tensor imaging implicates prefrontal axonal injury in executive function impairment following very mild traumatic brain injury. *Radiology*, *252*(3), 816-824.
48. Leahy, R. L., Tirch, D. D., & Melwani, P. S. (2012). Processes underlying depression: Risk aversion, emotional schemas, and psychological flexibility. *International Journal of Cognitive Therapy*, *5*(4), 362-379
49. Leonidou, C., Panayiotou, G., Bati, A., & Karekla, M. (2019). Coping with psychosomatic symptoms: The buffering role of psychological flexibility and impact on quality of life. *Journal of health psychology*, *24*(2), 175-187. https://doi.org/10.1177/1359105316666657
50. Lovibond, S.H. & Lovibond, P.F. (1995). Manual for the Depression Anxiety & Stress Scales. (2nd Ed.) Sydney: Psychology Foundation

51. Luoma, J., Drake, C. E., Kohlenberg, B. S., & Hayes, S. C. (2011). Substance abuse and psychological flexibility: The development of a new measure. *Addiction Research & Theory*, *19*(1), 3-13. https://doi.org/10.3109/16066359.2010.524956
52. MacMillan, P. J., Hart, R. P., Martelli, M. F., & Zasler, N. D. (2002). Pre-injury status and adaptation following traumatic brain injury. *Brain Injury*, *16*(1), 41-49. https://doi.org/10.1080/0269905011008812
53. Mah, K., Hickling, A., & Reed, N. (2018). Perceptions of mild traumatic brain injury in adults: a scoping review. *Disability and rehabilitation*, *40*(8), 960-973. https://doi.org/10.1080/09638288.2016.1277402
54. Mantua, J., & Ready, R. E. (2019). Emotion habituation is accelerated in chronic mild traumatic brain injury. *Brain injury*, *33*(11), 1467-1475. https://doi.org/10.1080/02699052.2019.1646434
55. Masuda, A., & Tully, E. C. (2012). The role of mindfulness and psychological flexibility in somatization, depression, anxiety, and general psychological distress in a nonclinical college sample. *Journal of Evidence-Based Complementary & Alternative Medicine*, *17*(1), 66-71. https://doi.org/10.1177/2156587211423400
56. McCracken, L. M., & Morley, S. (2014). The psychological flexibility model: a basis for integration and progress in psychological approaches to chronic pain management. *The Journal of Pain*, *15*(3), 221-234.).
57. McCracken, L. M., Williams, J. L., & Tang, N. K. (2011). Psychological flexibility may reduce insomnia in persons with chronic pain: a preliminary retrospective study. *Pain Medicine*, *12*(6), 904-912.
58. McCrea, M., Guskiewicz, K. M., Marshall, S. W., Barr, W., Randolph, C., Cantu, R. C., ... & Kelly, J. P. (2003). Acute effects and recovery time following concussion in collegiate football players: the NCAA Concussion Study. *Jama*, *290*(19), 2556-2563.
59. McCrea, M., Iverson, G. L., McAllister, T. W., Hammeke, T. A., Powell, M. R., Barr, W. B., & Kelly, J. P. (2009). An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. *The Clinical Neuropsychologist*, *23*(8), 1368-1390.
60. McCrea, M., Iverson, G. L., McAllister, T. W., Hammeke, T. A., Powell, M. R., Barr, W. B., & Kelly, J. P. (2009). An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. *The Clinical Neuropsychologist*, *23*(8), 1368-1390. https://doi.org/10.1080/13854040903074652
61. McInnes, K., Friesen, C. L., MacKenzie, D. E., Westwood, D. A., & Boe, S. G. (2017). Mild Traumatic Brain Injury (mTBI) and chronic cognitive impairment: A scoping review. *PloS one*, *12*(4). https://doi.org/10.1371/journal.pone.0174847
62. McMahon, P. J., Hricik, A., Yue, J. K., Puccio, A. M., Inoue, T., Lingsma, H. F., ... & Okonkwo and the TRACK-TBI investigators including, D. O. (2014). Symptomatology and functional

outcome in mild traumatic brain injury: results from the prospective TRACK-TBI study. *Journal of neurotrauma*, *31*(1), 26-33.

63. Meares, S., Shores, E. A., Taylor, A. J., Batchelor, J., Bryant, R. A., Baguley, I. J., ... & Marosszeky, J. E. (2008). Mild traumatic brain injury does not predict acute postconcussion syndrome. *Journal of Neurology, Neurosurgery & Psychiatry*, *79*(3), 300-306.
64. Merz, Z. C., Zane, K., Emmert, N. A., Lace, J., & Grant, A. (2019). Examining the relationship between neuroticism and post-concussion syndrome in mild traumatic brain injury. *Brain injury*, *33*(8), 1003-1011. https://doi.org/10.1080/02699052.2019.1581949
65. Mooney, C. F., Mooney, C. Z., Mooney, C. L., Duval, R. D., & Duvall, R. (1993). *Bootstrapping: A nonparametric approach to statistical inference* (No. 95). sage.
66. Morris, L., & Mansell, W. (2018). A systematic review of the relationship between rigidity/flexibility and transdiagnostic cognitive and behavioral processes that maintain psychopathology. *Journal of Experimental Psychopathology*, *9*(3), 2043808718779431.
67. Nelson, L. D., Temkin, N. R., Dikmen, S., Barber, J., Giacino, J. T., Yuh, E., ... & Okonkwo, D. O. (2019). Recovery after mild traumatic brain injury in patients presenting to US Level I trauma centers: A Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) study. *JAMA neurology*, *76*(9), 1049-1059
68. Ong, C. W., Lee, E. B., Levin, M. E., & Twohig, M. P. (2019). A review of AAQ variants and other context-specific measures of psychological flexibility. *Journal of Contextual Behavioral Science*, *12*, 329-346.
69. Ownsworth, T., Little, T., Turner, B., Hawkes, A., & Shum, D. (2008). Assessing emotional status following acquired brain injury: The clinical potential of the depression, anxiety and stress scales. *Brain Injury*, *22*(11), 858-869.
70. Özkan, S., Zale, E. L., Ring, D., & Vranceanu, A. M. (2017). Associations between pain catastrophizing and cognitive fusion in relation to pain and upper extremity function among hand and upper extremity surgery patients. *Annals of Behavioral Medicine*, *51*(4), 547-554.
71. Polich, G., Iaccarino, M. A., Kaptchuk, T. J., Morales-Quezada, L., & Zafonte, R. (2020). Nocebo effects in concussion: is all that is told beneficial?. *American Journal of Physical Medicine & Rehabilitation*, *99*(1), 71-80. 10.1097/phm.0000000000001290
72. Polinder, S., Cnossen, M. C., Real, R. G., Covic, A., Gorbunova, A., Voormolen, D. C., ... & Von Steinbuechel, N. (2018). A multidimensional approach to post-concussion symptoms in mild traumatic brain injury. *Frontiers in neurology*, *9*, 1113.
73. Ponsford, J., Cameron, P., Fitzgerald, M., Grant, M., Mikocka-Walus, A., & Schönberger, M. (2012). Predictors of postconcussive symptoms 3 months after mild traumatic brain injury. *Neuropsychology*, *26*(3), 304.

74. Ponsford, J., Nguyen, S., Downing, M., Bosch, M., McKenzie, J. E., Turner, S., ... & Green, S. (2019). Factors associated with persistent post-concussion symptoms following mild traumatic brain injury in adults. *Journal of rehabilitation medicine*, *51*(1), 32-39.
75. Randall, D., Thomas, M., Whiting, D., & McGrath, A. (2017). Depression Anxiety Stress Scales (DASS-21): factor structure in traumatic brain injury rehabilitation. *Journal of head trauma rehabilitation*, *32*(2), 134-144.
76. Rickards, T. A., Cranston, C. C., & McWhorter, J. (2020). Persistent post-concussive symptoms: A model of predisposing, precipitating, and perpetuating factors. *Applied Neuropsychology: Adult*, 1-11
77. Rolffs, J. L., Rogge, R. D., & Wilson, K. G. (2018). Disentangling components of flexibility via the hexaflex model: Development and validation of the Multidimensional Psychological Flexibility Inventory (MPFI). *Assessment*, *25*(4), 458-482.
78. Ruff, R. M., Iverson, G. L., Barth, J. T., Bush, S. S., Broshek, D. K., & NAN Policy and Planning Committee. (2009). Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology education paper. *Archives of clinical neuropsychology*, *24*(1), 3-10.
79. Sander, A. M., Clark, A. N., Arciniegas, D. B., Tran, K., Leon-Novelo, L., Ngan, E., Bogaards, J., Sherer, M., & Walser, R. (2020). A randomized controlled trial of acceptance and commitment therapy for psychological distress among persons with traumatic brain injury. *Neuropsychological Rehabilitation*, *0*(0), 1–25. https://doi.org/10.1080/09602011.2020.1762670
80. Sandoz, E. K., Wilson, K. G., Merwin, R. M., & Kellum, K. K. (2013). Assessment of body image flexibility: the body image-acceptance and action questionnaire. *Journal of Contextual Behavioral Science*, *2*(1-2), 39-48.
81. Scott, K. L., Strong, C. A. H., Gorter, B., & Donders, J. (2016). Predictors of post-concussion rehabilitation outcomes at three-month follow-up. *The Clinical Neuropsychologist*, *30*(1), 66-81
82. Scott, W., Hann, K. E., & McCracken, L. M. (2016). A comprehensive examination of changes in psychological flexibility following acceptance and commitment therapy for chronic pain. *Journal of contemporary psychotherapy*, *46*(3), 139-148. https://doi.org/10.1007/s10879-016-9328-5
83. Silverberg, N. D., & Iverson, G. L. (2011). Etiology of the post-concussion syndrome: physiogenesis and psychogenesis revisited. *NeuroRehabilitation*, *29*(4), 317-329
84. Silverberg, N. D., Gardner, A. J., Brubacher, J. R., Panenka, W. J., Li, J. J., & Iverson, G. L. (2015). Systematic review of multivariable prognostic models for mild traumatic brain injury. *Journal of neurotrauma*, *32*(8), 517-526.
85. Silverberg, N. D., Iverson, G. L., & Panenka, W. (2017). Cogniphobia in mild traumatic brain injury. *Journal of neurotrauma*, *34*(13), 2141-2146. https://doi.org/10.1089/neu.2016.4719
86. Silverberg, N. D., Panenka, W. J., & Iverson, G. L. (2018). Fear avoidance and clinical outcomes from mild traumatic brain injury. *Journal of neurotrauma*, *35*(16), 1864-1873.

87. Snell, D. L., Siegert, R. J., & Silverberg, N. D. (2020). Rasch analysis of the World Health Organization Disability Assessment Schedule 2.0 in a mild traumatic brain injury sample. *Brain injury*, *34*(5), 610-618.
88. Snell, D. L., Surgenor, L. J., Hay-Smith, E. J. C., & Siegert, R. J. (2009). A systematic review of psychological treatments for mild traumatic brain injury: an update on the evidence. *Journal of Clinical and Experimental Neuropsychology*, *31*(1), 20-38.
89. Snell, D. L., Surgenor, L. J., Hay-Smith, E. J. C., Williman, J., & Siegert, R. J. (2015). The contribution of psychological factors to recovery after mild traumatic brain injury: Is cluster analysis a useful approach? *Brain Injury*, *29*(3), 291–299. https://doi.org/10.3109/02699052.2014.976594
90. Stubbs, J. L., Green, K. E., Silverberg, N. D., Howard, A., Dhariwal, A. K., Brubacher, J. R., ... & Purcell, V. (2020). Atypical somatic symptoms in adults with prolonged recovery from mild traumatic brain injury. *Frontiers in Neurology*, *11*. https://doi.org/10.3389/fneur.2020.00043
91. Sullivan, K. A., Kaye, S. A., Blaine, H., Edmed, S. L., Meares, S., Rossa, K., & Haden, C. (2020). Psychological approaches for the management of persistent postconcussion symptoms after mild traumatic brain injury: a systematic review. *Disability and rehabilitation*, *42*(16), 2243-2251.
92. Sylvester, M. E. (2011). *Acceptance and commitment therapy for improving adaptive functioning in persons with a history of pediatric acquired brain injury* (Doctoral dissertation).
93. Te Ao, B., Brown, P., Tobias, M., Ameratunga, S., Barker-Collo, S., Theadom, A., ... & Feigin, V. L. (2014). Cost of traumatic brain injury in New Zealand: evidence from a population-based study. *Neurology*, *83*(18), 1645-1652. https://doi.org/10.1212/WNL.0000000000000933
94. Teo, S. H., Fong, K. N., Chen, Z., & Chung, R. C. (2020). Cognitive and psychological interventions for the reduction of post-concussion symptoms in patients with mild traumatic brain injury: a systematic review. *Brain injury, 34*(10), 1305-1321.
95. Theadom, A., Parag, V., Dowell, T., McPherson, K., Starkey, N., Barker-Collo, S., ... & BIONIC Research Group. (2016). Persistent problems 1 year after mild traumatic brain injury: a longitudinal population study in New Zealand. *Br J Gen Pract*, *66*(642), e16-e23. https://doi.org/10.3399/bjgp16X683161
96. Twohig, M. P., Vilardaga, J. C. P., Levin, M. E., & Hayes, S. C. (2015). Changes in psychological flexibility during acceptance and commitment therapy for obsessive compulsive disorder. *Journal of Contextual Behavioral Science*, *4*(3), 196-202.
97. Üstün, T. B., Kostanjsek, N., Chatterji, S., & Rehm, J. (Eds.). (2010). *Measuring health and disability: Manual for WHO disability assessment schedule WHODAS 2.0*. World Health Organization.
98. Vowles, K. E., & McCracken, L. M. (2008). Acceptance and values-based action in chronic pain: a study of treatment effectiveness and process. *Journal of consulting and clinical psychology*, *76*(3), 397

99. Whiting, D. L., Deane, F. P., Ciarrochi, J., McLeod, H. J., & Simpson, G. K. (2015). Validating measures of psychological flexibility in a population with acquired brain injury. *Psychological assessment*, *27*(2), 415. https://doi.org/10.1037/pas0000050

100. Whiting, D. L., Deane, F. P., Simpson, G. K., McLeod, H. J., & Ciarrochi, J. (2017). Cognitive and psychological flexibility after a traumatic brain injury and the implications for treatment in acceptance-based therapies: A conceptual review. *Neuropsychological rehabilitation*, *27*(2), 263-299.

101. Whiting, D., Deane, F., McLeod, H., Ciarrochi, J., & Simpson, G. (2020). Can acceptance and commitment therapy facilitate psychological adjustment after a severe traumatic brain injury? A pilot randomized controlled trial. *Neuropsychological rehabilitation*, *30*(7), 1348-1371.

102. Wicksell, R. K., Kemani, M., Jensen, K., Kosek, E., Kadetoff, D., Sorjonen, K., ... & Olsson, G. L. (2013). Acceptance and commitment therapy for fibromyalgia: a randomized controlled trial. *European journal of pain*, *17*(4), 599-611.

103. Wijenberg, M. L., Stapert, S. Z., Verbunt, J. A., Ponsford, J. L., & Van Heugten, C. M. (2017). Does the fear avoidance model explain persistent symptoms after traumatic brain injury?. *Brain injury*, *31*(12), 1597-1604. https://doi.org/10.1080/02699052.2017.1366551

104. Yehene, E., Lichtenstern, G., Harel, Y., Druckman, E., & Sacher, Y. (2019). Self-efficacy and acceptance of disability following mild traumatic brain injury: A pilot study. *Applied Neuropsychology: Adult*, 1-10. https://doi.org/10.1080/23279095.2019.1569523

105. Young, G. (2020). Thirty Complexities and Controversies in Mild Traumatic Brain Injury and Persistent Post-concussion Syndrome: a Roadmap for Research and Practice. *Psychological Injury and Law*, 1-25.

Table 1: Demographic and clinical characteristics of the sample (n=169)

Demographic Characteristics	
Age [Mean (SD, range]	35.2 (12.8, 18-69)
Sex (female) [N (%)]	111 (65.7%)
Ethnicity [N(%)]	
- NZ European	108 (63.9%)
- Other	61 (36.1%)
Marital Status [N(%)]	
- In a relationship	102 (60.4%)
- Single	67 (39.6%)
Education – n with post-secondary school qualification [N(%)]	108 (63.9%)
Pre-Injury Employment Status	
- Working	142 (84.0%)
- Not working	27 (16.0%)
Current Employment Status [N(%)]	
- Working	115 (68.0%)
- Not working	54 (32.0%)
Prior Mental Health History (yes) [N(%)]	83 (49.1%)
- Anxiety	71 (42.0%)
- Depression	66 (39.1%)
- OCD	3 (1.8%)
- PTSD	13 (7.7%)
- Eating Disorder	10 (5.9%)
- Substance Use Disorder	8 (4.7%
Prior Concussion History (yes) [N(%)]	73 (43.2%)
Medical History (yes) [N(%)]	52 (30.8%)
Clinical Characteristics	
Time Since Injury (weeks) [Mean (SD, range]	8.73 (10.57, 2.00 -103.0)
Mechanism of Injury	
- Assault	14 (8.3%)
- Transport accident	19 (12.3%)
- Fall	68 (43.9%)
- Hit by object	50 (32.3%)
- Other	18 (11.6%)
Other Injury Sustained (yes) [N(%)]	97 (57.4%)

Table 2: Self-reported measures: Mean, standard deviations, and range.

Measure	Mean (SD)	Range
Rivermead Post-Concussion Questionnaire	28.7 (14.6)	0.00 - 64.0
WHODAS (2.0)	18.6 (4.5)	0.00 – 38.0
AAQ-ABI (RA)	10.1 (3.5)	0.00 – 22.4
AAQ-II	22.2 (10.9)	9.00 – 51.0
DASS-21: Anxiety	5.76 (4.80)	0.00 – 21.0
DASS-21: Stress	8.85 (5.11)	0.00 – 21.0
DASS-21: Depression	6.59 (6.08)	0.00 – 21.0

WHODAS (2.0) = WHO Disability Schedule; AAQ-ABI (RA) = Acceptance and Action Questionnaire – Acquire Brain Injury (Reactive Avoidance); AAQ-II = Action and Acceptance Questionnaire; DASS = Depression, Anxiety and Stress Scale

Table 3. Multiple linear regression models of post-concussion symptoms and functional status

Outcome Variable	**Parameter**	**Estimate**	**SE**	**T Value**	**P Value**	**LCI**	**UCI**	**R-Sq**
Post-Concussion Symptoms (RPQ)	Gender	2.27	1.77	1.28	.201	-1.22	5.76	
	Age	-0.04	0.07	-0.50	.620	-0.17	0.103	
	Other Injury	-2.70	1.76	-1.53	.128	-6.18	0.78	
	Concussion History	0.59	1.72	0.34	.734	-2.82	3.99	
	Medical History	-3.70	1.84	-2.01	.046*	-7.33	-0.07	
	Mental Health History	1.02	1.75	0.59	.559	-2.43	4.48	
	DASS-S	1.33	0.27	4.91	<.001**	0.79	1.86	
	DASS-A	0.34	0.26	1.33	.185	-0.17	0.85	
	DASS-D	0.03	0.24	0.11	.914	-0.44	0.49	
	AAQ-ABI(RA)	1.06	0.35	3.03	.003**	0.37	1.74	
	AAQ-II	-0.12	0.13	-0.98	.328	-0.37	0.13	.499

Functional status (WHODAS 2.0)	Gender	0.98	0.58	1.68	.094	-0.17	2.12	
	Age	0.01	0.02	0.33	.741	-0.04	0.05	
	Other Injury	-0.78	0.58	-1.35	.178	-1.92	0.36	
	Concussion history	0.91	0.57	1.61	.109	-0.21	2.03	
	Medical History	-0.50	0.60	-0.83	.410	-1.70	0.70	
	Mental Health History	0.38	0.57	0.70	.504	-0.75	1.52	
	DASS-S	0.70	0.09	0.79	.434	-0.11	0.25	
	DASS-A	0.20	0.09	2.31	0.02*	0.03	0.36	
	DASS-D	0.10	0.08	1.32	.190	-0.05	0.26	
	AAQ-ABI(RA)	0.48	0.11	4.23	<.001**	0.26	0.71	
	AAQ-II	0.03	0.04	0.62	.538	-0.06	0.12	.536

* p<.05, ** p<.01

RPQ = Rivermead Post Concussion Questionnaire; WHODAS (2.0) = WHO Disability Schedule; DASS = Depression, Anxiety and Stress Scale; ; AAQ-ABI (RA) = Acceptance and Action Questionnaire – Acquire Brain Injury (Reactive Avoidance); AAQ-II = Acceptance and Action Questionnaire LCI = Lower Confidence Interval; UCI = Upper Confidence Interval

Table 4. Total, direct, and indirect effects of psychological distress on post-concussion symptoms and functional status using psychological flexibility as indirect effect

Y	X	m	a path coefficient	b path coefficient	Total effect (c)	Direct effect (c')	Indirect effect		
								CI (95%)	
							Effect (SE)	LCI	UCI
Post-Concussion Symptoms	Stress	Psychological Flexibility			1.75**	1.41**	0.35**	0.05	0.70
		AAQ-ABI (RA)	0.45**	0.98**			0.44**	0.15	0.74
		AAQ-II	1.35**	-0.07			-0.09	-0.33	0.15
	Anxiety	Psychological Flexibility			1.52**	0.88**	0.65**	0.32	0.98
		AAQ-ABI (RA)	0.44**	1.46**			0.63**	0.35	1.00
		AAQ-II	1.41**	0.01			0.01	-0.26	0.30
	Depression	Psychological Flexibility			1.11**	0.49*	0.63**	0.25	1.00
		AAQ-ABI (RA)	0.38**	1.61**			0.62**	0.34	0.88
		AAQ-II	1.36**	0.01			0.01	-0.32	0.34
Functional status	Stress	Psychological Flexibility			0.54**	0.18*	0.35**	0.22	0.50
		AAQ-ABI (RA)	0.45**	0.56**			0.26**	0.17	0.41
		AAQ-II	1.35**	0.07**			0.10	-0.02	0.23
	Anxiety	Psychological Flexibility			0.59**	.026**	0.32**	0.21	0.44
		AAQ-ABI (RA)	0.44**	0.56**			0.24**	0.11	0.39
		AAQ-II	1.41**	0.06			0.08	-0.03	0.20
	Depression	Psychological Flexibility			0.46**	0.15*	0.31**	0.19	0.45

	AAQ-ABI (RA)	0.38**	0.61**			0.23**	0.12	0.38
	AAQ-II	1.36**	0.06			0.08	-0.04	0.19

* p<.05

** p<.01

AAQ-ABI (RA) = Acceptance and Action Questionnaire – Acquire Brain Injury (Reactive Avoidance; LCI = Lower Confidence Interval; UCI = Upper Confidence Interval

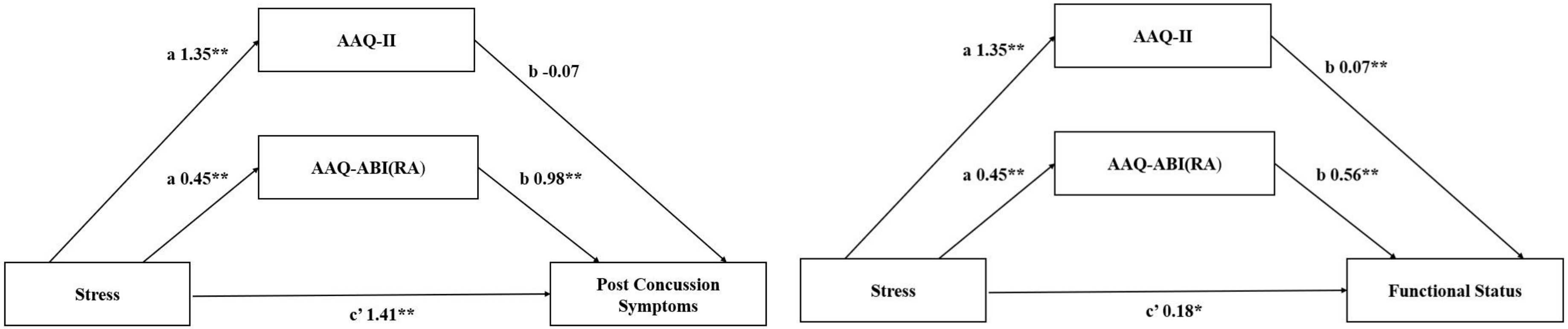

Figure 1: Direct and indirect effect of stress on post-concussion symptoms and functional status.

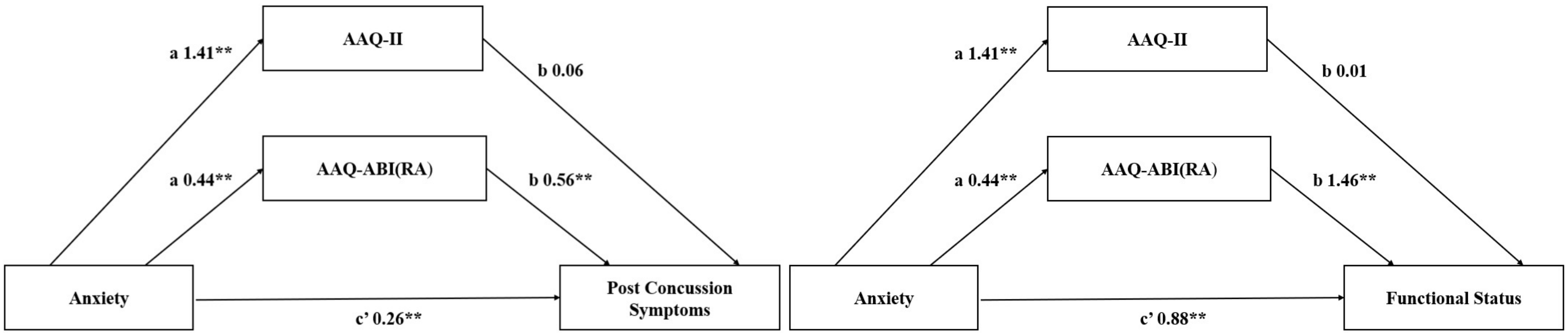

Figure 2: Direct and indirect effect of anxiety on post-concussion symptoms and functional status.

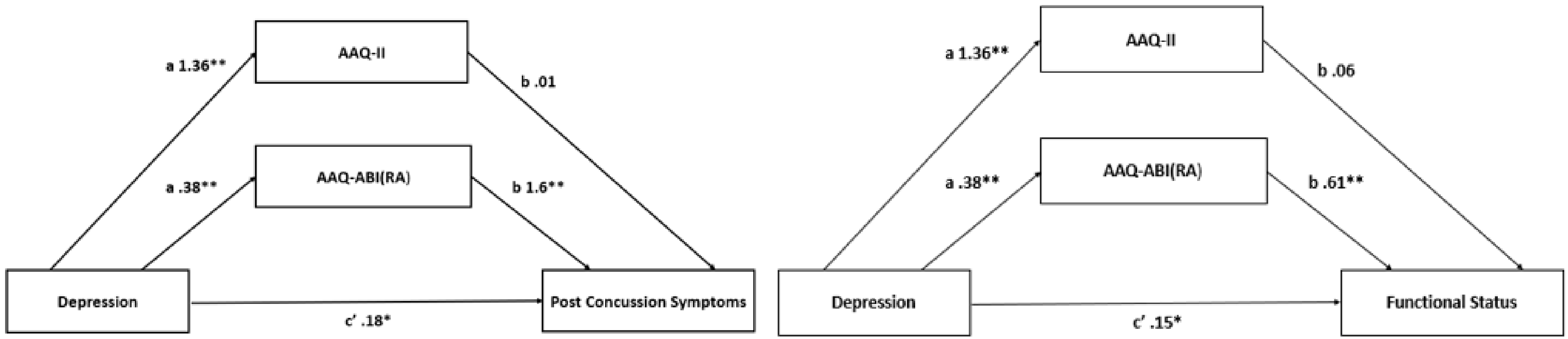

Figure 3: Direct and indirect effect of depression on post-concussion symptoms and functional status.