Mild Head Injury and Underarousal: Effects on Decision-Making

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Background

Globally, approximately 57 million individuals are hospitalized annually due to head trauma[1], with 80 to 90% of injuries given a classification of "mild"[2,3]. Moderate to severe injuries typically introduce a broad sequelae of physical, cognitive, behavioural, and affective complications which limit optimal social functioning.

During closed head injury events, the ventral prefrontal cortex (VPFC) is highly susceptible to functional disruption due to its proximal relation to the orbital bones of the skull[4]. The VPFC, including the orbitofrontal cortex (OFC), are involved in processing socio-emotional information, modulating affective arousal, and regulating adaptive behaviour with respect to environmental demands[5,6].

Clinical and traumatic cases suggest that OFC dysfunction is associated with a proclivity toward disinhibited antisocial behaviour[7] and atypical choice characteristics in socio-emotional contexts such as devoting less time to considering moral dilemmas and being more likely to commit moral transgressions[8,9,10].

Trauma to the VPFC does not necessarily disrupt to ability for one to emotionally respond to the environment, but has been shown to relate to attenuated anticipatory somatic responses associated with the affective/motivational significance of future events[11,12].

There is little debate about the functional consequences in individuals who present with physical evidence of neural injury, but there is a paucity of research into the potential socio-emotional ramifications of milder injuries. Competent individuals who report a history of MHI resulting in an altered state of consciousness (ASC) present with impaired neuropsychological performance[13,14,15] and atypical electro-cortical responses[16,17].

Thus, functional disruption of the brain can lead to performance limitations in the absence of observable tissue damage and MHIs that produce an ASC may be sufficient to produce neuropsychological and neurophysiological impairments.

Purpose

To examine the relationships between neuropsychological performance, physiological arousal, and decision-making behaviours in university students, who do and do not report a history of MHI.

Hypotheses

1. The MHI and non-MHI groups do not differ in their general cognitive performance.
2. Those reporting a history of MHI will self-report a higher propensity for disinhibited and antisocial behaviours.
3. History, and severity, of MHI will be related to poorer decision-making.
4. The MHI group will be physiologically underaroused, relative to the non-MHI group particularly when anticipating potential consequences to future decisions.
5. Individuals who report a history of MHI will spend less time deciding on a course of action, and demonstrate less reticence, for personal moral dilemmas.

Methods

Forty-four Brock University students (33 females, 11 males), with 41% (n = 18) reporting a history of MHI resulting in an ASC, participated in this study.

Measures

Neuropsychological:
- Design Fluency[18]
- Iowa Gambling Task (IGT)[19]

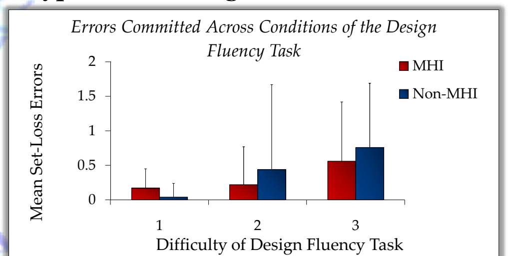
Psychophysiological:
- Electrodermal Activity (EDA)[20]

Behavioural and Questionnaires:
- Social Dilemmas[10]
- Social Problem Solving Inventory[21]
- Barratt Impulsiveness Scale – 11 (Motor)[22]
- Self-Report Psychopathy Checklist (Antisocial Behaviour & Erratic Lifestyle)[23]

Have you ever had a head injury resulting in an altered state of consciousness (including: vomiting, dizziness, seeing stars, confusion)?

Results

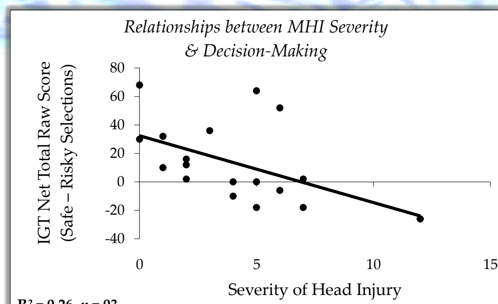
Hypothesis 1: Cognitive Performance



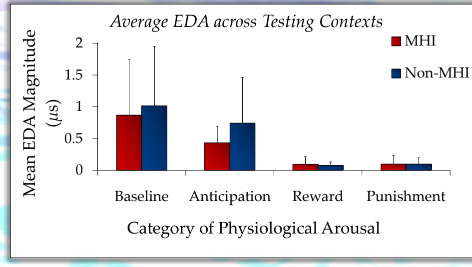
Number of designs that did not meet the accuracy criteria for MHI (n = 18) and non-MHI (n = 25) across difficulty of design fluency. There was a main effect of Difficulty ($F(2, 82) = 6.17$, $p < .01$, $\eta^2 = .13$) with significantly more errors being made between the 1st and 3rd condition ($p < .01$) for both groups.

Hypothesis 2 and 3: Social Behaviours and Decision-Making

Investigating self-reported disinhibited and antisocial behaviours revealed that no between group comparisons achieved statistical significance. Similarly, overall decision-making performance did not vary as a function of MHI. However, self-reported injury severity was associated with decision-making performance.

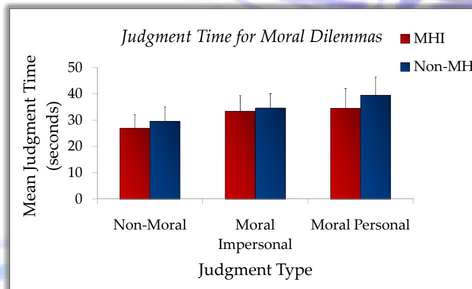


Hypothesis 4: Sympathetic Arousal

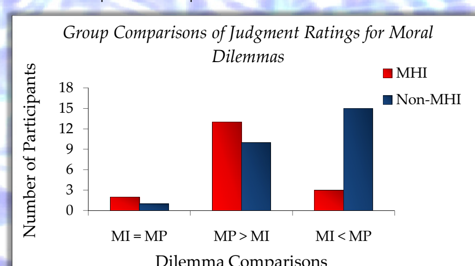


Baseline analysis: MHI (n = 18) and non-MHI (n = 25); anticipation analysis: MHI (n = 14) and non-MHI (n = 20); reward and punishment analysis: MHI (n = 17) and non-MHI (n = 25). Mean EDA magnitude was significantly differently only for anticipatory arousal ($p < .05$).

Hypothesis 5: Moral Judgements



There was a main effect of Judgment Type ($F(1.7, 71.5) = 85.54$, $p < .001$, $\eta^2 = .67$), a trend for Group ($F(1,42) = 2.94$, $p = .09$, $\eta^2 = .06$), and a significant interaction ($F(1.7, 71.5) = 3.55$, $p = .04$, $\eta^2 = .08$). Compared to non-injured individuals, the MHI group was significantly faster to make a judgment for moral personal dilemmas, $t(42) = 2.24$, $p = .03$; and made these decisions as quickly as impersonal ones. Non-MHI subjects were more reticent to make personal than impersonal decisions.



Contrary to the non-MH group, the MHI group rated themselves as more likely to engage in a personal moral transgression (e.g., smother their child in order to save a group of refugees) compared to impersonal moral transgressions (e.g., taking the money in a wallet that was found before returning it), χ^2 (df) = 7.52, p = .02.

Discussion & Implications

History of MHI did not relate to impaired cognitive performance, or increased ratings of antisocial behaviour. These results might be explained by the subtlety of injury and/or the sample being comprised of university students.

Self-reported head injury severity is negatively associated with success making good choices in a gambling paradigm – an indicator of OFC dysfunction in persons with acquired brain injury[12].

Further, these favourable decisions may be contingent on preparedness since, in line with previous research involving moderate to severe cases of VPFC injury[5,11,12], our findings suggest that while individuals with a history of MHI have comparable physiological responses to feedback (rewards and punishments), they nevertheless have attenuated somatic activation when anticipating making a decision.

The VPFC is uniquely engaged for moral dilemmas and individuals with injury to the VPFC have atypical choice characteristics in socio-emotional contexts[8,9,10]. We found that individuals reporting history of MHI responded differentially to non-moral versus moral dilemmas, but not within moral dilemmas (impersonal versus personal), suggesting that MHI may interfere judgments based on emotional input (i.e., in situations where personal harm may be incurred). Similar to previous findings from persons with VPFC injury[9], individuals reporting head trauma took longer to make a moral decision than a neutral one, but did not differentially respond (in terms of time or choice) to personal, direct transgressions as compared to outcomes which would only result in an indirect, non-physical, harm.

Conclusions

Together, these findings support the argument that a history of MHI can differentially impact physiological and psychological mechanisms which sustain adaptive social decision-making.

Examining patterns of neuropsychological/physiological limitations in university students who have sustained milder injuries provides insight in the capacity of brain function which is not masked by more extensive and complicated traumatic injury.

The current results reflect findings from more traumatic injury cases suggesting that head injury can be placed on a continuum of brain injury severity.

References

[1]Langlois et al. (2006).*Journal of Head Trauma Rehabilitation, 21*, 375-378.
[2]Cassidy et al. (2004). *Journal of Rehabilitation Medicine, 43*, 28-60.
[3]Bazarian et al. (2005). *Brain Injury, 19*(2), 85-91.
[4]Morales et al. (2007). *eMedicine.*
[5]Wallis et al. (2007). *Annual Review of Neuroscience, 30*, 31-56.
[6]Barbas et al. (2003). *BioMed Central Neuroscience, 4*(25), 1471-2202.
[7]Blair (2004). *Brain and Cognition, 55*, 198-208.
[8]Koenigs et al. (2007). *The Journal of Neuroscience, 24*(4), 951-956.
[9]Ciaramelli et al. (2007). *Social and Cognitive Affective Neuroscience, 2*, 84-92.
[10]Greene et al. (2001). *Science, 293*, 2105-2108.
[11]Bechara et al. (1996). *Cerebral Cortex, 6*, 215-225.
[12]Bechara (2004). *Brain and Cognition, 55*, 30-40.
[13]Bernstein (1999). *Brain Injury, 13*(3), 151-172.
[14]Ptito et al. (2007). *NeuroRehabilitation, 22*, 217-227.
[15]Segalowitz et al. (1995). *Journal of Learning Disabilities, 28*, 309-319.
[16]Segalowitz et al. (2001). *Brain and Cognition, 45* (3), 342-356.
[17]Bernstein (2002). *Journal of the International Neuropsychological Society, 8*, 673-682.
[18]Delis et al. (2001). DKEFS San Antonio, TX: Psychological Corporation.
[19]Bechara (2007). IGT. Lutz, FL: Psychological Assessment Resources, Inc.
[20]Polygraph Professional Suite. Limestone Technologies Inc.:Odessa, Ontario, Canada.
[21]D'Zurilla et al. (2002). *SPSI-R: Technical Manual*. North Tonawanda, NY: Multi-Health Systems.
[22]Patton et al. (1995). *Journal of Clinical Psychology, 51*(6), 768-774.
[23]Paulhus et al. (2007). *Manual for SRPS.* Toronto, Ontario, Canada: Multi-Health Systems.

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