Return-to-driving expectations following mild traumatic brain injury

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Abstract

Aim: Although individuals recovering from mild traumatic brain injury (MTBI) could pose a risk to road safety, little is known about their intentions regarding return-to-driving. Reported are the expectations of a sample of emergency department patients with MTBI regarding their recovery and return-to-driving.

Method: Eighty-one patients with MTBI were recruited from an emergency department. Participants completed an 11-item questionnaire measuring expectations regarding recovery from injury; five of the items addressed return-to-driving.

Results: Only 48% of the sample intended to reduce their driving following their injury. However, those that did intend to reduce their driving nominated a mean duration of 16.59 days ($SD = 31.68$) of reduced exposure. A logistic regression found that previous head injury experience and an interaction between pain and previous head injury experience predicted intentions to reduce driving. Similarly, a multiple regression revealed that pain level contributed significantly to the variance in time estimates of return-to-driving.

Conclusion: The finding that half the individuals recovering from MTBI do not intend to moderate their driving exposure post-injury is cause for concern, as another study has shown that driving performance is compromised in this group immediately after injury.

Introduction

Mild traumatic brain injury (MTBI) occurs when a head impact is forceful enough to momentarily disrupt brain function. It is a common injury; conservative estimates put its annual incidence rate at 100 to 300 MTBIs per 100 000 people, but the rate may be as high as 1750 per 100 000 people if non-hospitalized cases are included [1, 2]. In the weeks after injury, MTBI is associated with cognitive impairments across a number of domains, including attention, executive functioning, fluency, memory, language, visuospatial skill, and global cognitive ability [3]. Recently, it was reported that individuals with MTBI were 0.45 seconds slower to anticipate traffic hazards than orthopaedic-injured controls in a computer-based hazard perception test (which is equivalent to a difference of 7.50 m in braking distance difference if driving at 60 km/hour) [4]. As worse hazard perception test performance has been consistently found to relate to an increased crash risk [5-8], drivers recovering from a recent MTBI may pose a risk to road safety if incompletely recovered. Knowledge of their return-to-driving intentions could help establish whether there is a need to educate drivers who have recently sustained MTBI.

Previous research attempting to gauge people's opinions regarding brain injury has focused mainly on determining the extent to which members of the public misunderstand the consequences of brain injury or react negatively towards a person with a brain injury [9-11]. Other studies concerned exclusively with MTBI have tended to focus on determining the extent to which post-concussive symptoms can be identified by laypersons [12-15]. The findings that there is poor community knowledge of the symptoms of brain injury generally [9], and of MTBI specifically [13], suggest that many individuals with MTBI may not be aware of the need to appropriately modify their behaviour in the recovery period. For example, Sye et al. reported that the majority of their sample of high school rugby players indicated that they had at some stage returned to play after a concussion without medical

clearance or against medical advice [15]. Furthermore, almost a third of the players thought that the importance of the game should impact on return-to-play decisions.

We posited that such unsafe attitudes could also extend to return-to-driving after MTBI and, in this study, report the expectations of a sample of emergency department patients with MTBI regarding their recovery and return-to-driving. We investigated whether gender, age, education, and previous head injury experience affected return-to-driving expectations, as previous studies have found knowledge about and attitudes toward brain injury to vary in relation to such personal characteristics [9, 11]. We also sought to determine whether acute injury characteristics observable by the patient (self-reported loss of consciousness, self-reported post-traumatic amnesia, pain, and emotionality) and objective cognitive performance (Galveston Orientation and Amnesia Test score, Hazard Perception Test response time, and information processing speed) influenced the patients' expectations.

Method

Participants

Patients with MTBI were recruited from the emergency department of the Royal Brisbane and Women's Hospital between April 2008 and August 2011. Participants were unpaid volunteers.

Full inclusion criteria are listed elsewhere [4]. Briefly, participants had to have been injured within 24 hours of recruitment, have an independent diagnosis of closed head injury (i.e., an injury where the skull is not penetrated and the brain is not exposed) with an initial Glasgow Coma Scale score of 13 to 15 [16], be aged 18 to 65 years, have a driver's licence, have a blood alcohol concentration less than 0.05% at the time of recruitment, and not be affected by any other conditions that could affect their performance at the time of testing (e.g. previous neuropathology or a hearing impairment).

Of the 125 eligible MTBI patients recruited, 38 were excluded as they did not complete the recovery questionnaire before they were discharged from the emergency department or because a staff member wanted to treat them during testing; three patients elected to cease participation because of increased pain, nausea, or tiredness; two patients ceased participation as visitors had arrived; and one patient ceased participation as they wished to leave hospital without further treatment. Participants were most commonly injured by assault (52%), falls (21%), road traffic collisions (12%), and participation in sport (12%). Participant characteristics are described in table 1.

Insert table 1 about here

Materials and Procedure

The hospital and the university ethics committees approved the study. The study protocol was fully described previously [4]. Testing was undertaken while the participants were awaiting medical treatment. Participants completed a 40 minute test battery of driving, cognitive, and injury-related measures (including the recovery questionnaire). Current pain and emotionality were measured by two 11-point self-report scales, ranging from 0 = no pain/no problems to 10 = severe pain/many problems. Self-report data were gathered during a short interview. The study protocol required that testing be stopped if emergency department staff wanted to treat a participant or if a participant was discharged, but testing was generally robust to short interruptions. Medical staff in the emergency department of the Royal Brisbane and Women's Hospital do not advise patients with MTBI on return-to-driving.

Expectations for recovery questionnaire. Participants completed an 11-item self-report questionnaire developed for the current study on their expectations regarding recovery from their injury (see Appendix). Five of the items explicitly address respondents' opinions on driving after an injury.

Galveston Orientation and Amnesia Test. The 16-item Galveston Orientation and Amnesia Test is a measure of the depth of post-traumatic amnesia [17]. Items assess participants' recall of events both before and after the injury, and participants' orientation to person, place, and time. Reliability was acceptable for the current sample, Cronbach's $\alpha = 0.74$. The scale is scored out of 100, with lower scores indicating higher levels of amnesia and disorientation.

University of Queensland Hazard Perception Test. The computer-based University of Queensland Hazard Perception Test presents genuine traffic scenes filmed from the driver's point of view. The 22-minute test includes 24 unambiguous traffic conflicts (defined as situations in which a collision or near collision between the camera car and another road user would eventually occur). Participants were required to use a computer mouse to click on any road users causing a traffic conflict as quickly as possible. Since experienced drivers perform better than novices on the HPT, it is regarded as a valid measure of a driving-related skill [18]. Reliability was also acceptable for the current sample, Cronbach's $\alpha = 0.85$. The outcome measure was individuals' mean response time to the traffic conflicts.

Digit Symbol Substitution Test. The Digit Symbol Substitution Test (from the Wechsler Adult Intelligence Scale–Revised) is an information processing speed task [19]. Participants were given 90 seconds in which to transcribe 93 symbols, using a digit-symbol key. The number of correctly transcribed symbols was scored.

Results

Analyses were performed using SPSS version 20. For all analyses, $\alpha = 0.05$ (two-tailed). In instances where participants provided inexact answers to the items in the recovery questionnaire, we used the mean of a time range (e.g. "1 to 2 weeks" became 10.50 days) or data were coded as missing when vague answers were given (e.g. "few weeks"). Participants' responses to the recovery questionnaire are in table 1.

Expectations for recovery and return-to-driving

We compared participants' expectations of recovery and return-to-driving intentions to a hypothesized 'no injury state' (i.e. that an uninjured group would report 0 days 'recovery' time and no intention to reduce their activity levels). One-sample testing was conducted because it was not feasible to recruit uninjured controls to complete the post-injury recovery questionnaire and, in this particular study, orthopaedic-injured individuals were not an appropriate control group (as orthopaedic injuries would also interfere with driving and other activities). One-sample binomial tests were conducted for the categorical variables and one-sample Wilcoxon signed rank tests were conducted for the continuously-scaled variables (see table 1).

In comparison to the no injury state, many participants with MTBI indicated that they would take time off work, reduce participation in their other activities, or reduce their driving. Similarly, participants' estimates of recovery time, time that they would spend off work, time that their other activities would be reduced for, and time that their driving would be reduced for were significantly different from the no injury state. Compared to the no injury state, 48% of participants with MTBI indicated that they would reduce their driving post-injury, spending 16.59 days (SD = 31.68) on average either not driving or driving but in a reduced capacity (e.g. short journeys only).

To ascertain whether the participants believed that MTBI could impair a person's mental ability to drive as compared to the effect of a minor limb injury, the participants' responses for the last two items in the recovery questionnaire were compared. A related-measures Wilcoxon signed rank test revealed that the participants did not rate MTBI as impairing a person's mental ability to drive for significantly longer than a minor limb injury, $z = -0.39$, $p = 0.70$.

Predictors of return-to-driving intentions

In order to assess whether personal characteristics, injury-related variables, or measures of cognitive performance could predict return-to-driving estimates, we first examined the bivariate correlation matrix for likely predictors (see table 2). Twenty-five cases with missing data-points (comprising 2.27% of the total dataset) were instantiated using multiple imputation. Predictors that were significantly related (or tending to significance, $p < 0.10$, given the modest sample size) to the categorical ‘reduce driving’ dependent variable or the continuously-scaled estimate of how long participants would reduce driving were selected for inclusion in subsequent analyses.

Insert table 2 about here

A logistic regression was conducted with participants’ intention to reduce driving (no or yes) as the criterion and two predictors: previous head injury (no or yes) and pain. Thirty-nine participants with MTBI who intended to reduce driving and 42 participants with MTBI who did not intend to reduce driving were available for analysis. Although gender was related to the intention to reduce driving, it could not be included in the logistic regression as this resulted in incomplete information about the predictors (i.e. there were too few females to populate most cells in the analysis, resulting in an unacceptably large standard error). Initial analyses suggested that the assumptions of logistic regression were met. Two potentially influential cases were identified, but when the logistic regression was repeated with these two cases removed, the same pattern of results was found. Therefore, we report the original analysis. As shown in Table 3, the logistic regression revealed a statistically reliable model, $\chi^2(3) = 21.09$, $p < 0.001$, with the significant predictor previous head injury and a significant interaction between previous head injury and pain. Those who had not experienced a previous head injury were more likely to intend to reduce driving than those who had a previous head injury (61% vs. 38%, respectively). However, this was qualified by the additional finding that those who had experienced a previous head injury were more likely to

intend to reduce driving if they also reported higher levels of pain. The mean pain level was 5.29 (SD = 2.29) for participants with a previous head injury who intended to reduce driving, 2.89 (SD = 2.08) for participants with a previous head injury who did not intend to reduce driving, 3.89 (SD = 2.63) for participants without a previous head injury who intended to reduce driving, and 4.36 (SD = 2.06) for participants without a previous head injury who did not intend to reduce driving (where 0 = no pain and 10 = severe pain).

Insert table 3 about here

Second, a multiple regression was conducted with participants' estimate of how long they would reduce driving for (measured in days) as the criterion and two predictors: pain and digit-symbols correct. Initial assumption checks revealed the criterion to be positively skewed and presence of two outliers. However, when the analysis was replicated with this variable subject to logarithmic transformation and the outliers removed, the pattern of results remained consistent with the original analysis that included the untransformed variable and outliers. Therefore, we report the original analysis. R was significantly different from zero, $R = 0.47$, $F(2, 78) = 11.36$, $p < 0.001$ (adjusted $R^2 = 0.20$). However, the only significant predictor was pain ($\beta = 0.43$, $p < 0.001$, 95% confidence interval for $\beta = 0.23$ to 0.63); digit-symbols correct did not explain a significant portion of the variance in intention to reduce driving once we accounted for the influence of pain. Pain explained 19% of the unique variation in participants' estimate of how long they would reduce driving for.

Discussion

We asked a sample of emergency department patients with MTBI to detail their expectations regarding recovery and return-to-driving. We found that about half of the sample indicated that they would take time off work, reduce their participation in other activities, and reduce their driving. Participants indicated that they would spend a number of days either not participating in these activities or participating in these activities but in a

reduced capacity. However, participants did not rate MTBI as impairing a person's mental ability to drive for significantly longer than a minor limb injury.

We also investigated the extent to which personal characteristics, injury-related variables, and cognitive tests could predict return-to-driving intentions. Previous head injury experience and an interaction between pain and previous head injury experience accounted for variance in responses to the categorical 'reduce driving' question. While participants who had not experienced a previous head injury were more likely to intend to reduce driving than participants who had a previous head injury, those who had experienced a previous head injury were more likely to intend to reduce driving if they also reported higher levels of pain. Similarly, pain was found to be a significant predictor of the time estimate of how long participants would reduce driving for post-injury. Participants who nominated higher levels of pain at the time of testing were more likely to intend to reduce their driving exposure for a number of days post-injury. This finding, that participants who had experienced a previous head injury were less likely to intend to reduce driving, contrasts with previous studies that have found knowledge and attitudes towards brain injury to be improved in those with prior experience of brain injury [9, 11]. Additionally, this study's findings suggest that acute injury characteristics, such as level of pain, may be of more relevance to predicting intentions in the recovery period. Indeed, another recent study found that pain assessed in the emergency department also predicted post-concussive symptoms at 3-months post-injury [20].

The current study's findings offer some cause for concern regarding the road safety of individuals recovering from MTBI. Previous research has shown that individuals with MTBI were 0.45 seconds slower to anticipate traffic hazards than orthopaedic-injured controls within 24 hours of injury [4]. Despite this evidence of an impairment in anticipatory driving skills immediately post-MTBI, about 4% of the participants in the current study responded that a minor head injury or concussion did not impair a person's mental ability to drive, while

36% indicated that any impairment would only last up to 24 hours. Furthermore, and perhaps most tellingly, 52% of the participants responded that they would not reduce their driving at all after their own recent MTBI. The attitudes and intentions expressed by the participants appear to be unsafe in light of previous findings [4]. If such attitudes and intentions are widely held by individuals at high risk of MTBI, then there is the potential risk that individuals will not moderate their driving exposure while their anticipatory skills are impaired (and, thus, are at risk of injuring other road users or re-injuring themselves).

We also found that there was no significant correspondence between performance on measures of cognition and return-to-driving intentions. In particular, there was no correlation between participants' Hazard Perception Test response times and their intentions to reduce driving, suggesting that participants lacked insight into their hazard perception ability post-MTBI. This finding complements similar findings from a sample of community-dwelling older drivers, where there was no significant relationship between hazard perception performance and older drivers' self-ratings [21]. Together, such findings suggest that drivers without gross cognitive deficits (i.e., otherwise healthy older drivers and drivers with MTBI) have limited insight into their driving ability. Again, this signals that there is the potential risk that individuals with MTBI will not moderate their driving exposure while their driving skills are impaired.

Before considering the implications of the current study, there are a few methodological limitations that need to be addressed. A potentially controversial methodological choice was the terms we adopted to define MTBI in the item assessing participants' opinion as to how long they believed that injury's mental effect on driving to last. We chose the terms 'concussion' and 'minor head injury', as 'mild traumatic brain injury' is not as well understood [22]. However, other studies have found that participants' responses to brain injury can be influenced by the terms used [11, 22]. McLellan et al. found

that the term ‘brain injury’ was evaluated more negatively than ‘head injury’ [11]. Similarly, Weber and Edwards reported that outcome expectations were more negative for ‘mild traumatic brain injury’ than ‘concussion’ or ‘minor head injury’ [22]. Consequently, the current study’s participants may have evaluated ‘concussion or minor head injury’ more favourably than if they had been presented with the descriptors ‘minor brain injury’ or ‘mild traumatic brain injury’.

The generalizability of our findings is somewhat limited by the inclusion criteria that we adopted, yet the criteria were chosen so as to exclude patients with conditions (other than a recent MTBI) that could reasonably be expected to affect their responses in the research study or for ethical reasons [4]. A further limitation of this particular study was the recruitment of individuals presenting to an inner metropolitan hospital’s emergency department. Individuals living in metropolitan areas that are well-serviced by public transport may be more willing to reduce their driving after MTBI than similarly-injured individuals residing in areas lacking such infrastructure (e.g. outer metropolitan, regional, or rural areas). This supposition could be tested by collecting data from regional and rural hospitals in future studies.

The sample recruited for the current study may be unusual due to the high proportion of participants injured via assault (52%) and the low number of females (10%). The high rate of injuries resulting from assault most likely reflects the fact that the emergency department is in close proximity to Brisbane’s main entertainment district and participants were recruited on weekends [4]. Other studies of MTBI conducted in inner city hospitals have similarly elevated rates of assault [20, 23]. While being involved in an assault may suggest that an individual takes more risks (and, thus, is less likely to intend to reduce driving while recovering from MTBI), this may also be true of individuals with injuries resulting from road traffic collisions (which is thought to be more common in the MTBI literature) That is, road

traffic collisions may result from risky driving. Thus, it is not necessarily the case that risk takers were over-represented in our sample. Nevertheless, future studies of driving intentions after MTBI may benefit from the inclusion of a risk-taking measure. Another approach would be to recruit enough participants for each external cause (e.g. assault, road traffic collision, fall, sports injury, etc.) to allow separate analyses within each group. It is unclear as to why only low numbers of females with MTBI could be recruited for the current study (yet assault injuries are typically associated with males, and half of the sample had been injured via assault), and this large gender imbalance precluded the inclusion of gender as a predictor in the logistic regression. Future studies should attempt to recruit a sufficient number of females with MTBI, perhaps by recruiting from emergency departments that are not located in the inner city.

Ideally, prospective longitudinal studies should measure the correspondence between individuals with MTBI's intentions regarding return-to-driving immediately post-injury and their actual driving behaviours during the weeks after injury (ethics requirements operating in the organisation that we collected data from prohibited us from collecting these follow-up data ourselves). Nevertheless, the current study suggests that individuals who have sustained MTBI may benefit from a brief educational intervention regarding return-to-driving (perhaps as they are discharged from the emergency department). The educational intervention could as simple as a patient information sheet listing the signs and symptoms of MTBI and suggesting activity limits for the short-term after injury [24]. Other educational interventions provided soon after MTBI have been found to be effective in the amelioration of persisting difficulties [25].

In summary, although individuals recovering from MTBI could pose a risk to road safety, little is known about their intentions and opinions regarding driving after injury. The present study found that almost half of those with recent MTBI responded that they would

not reduce their driving at all after their injury. Therefore, we contend that there is a risk that such individuals are not moderating their driving exposure while they are recovering from MTBI.

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Declaration of Interest statement

The authors report no declarations of interest.

Appendix

RECOVERY QUESTIONNAIRE

Please answer the following questions as honestly and accurately as possible. There are no right or wrong answers.

1. How long do you believe it will take for you to recover from your injury? _____
2. Will you take time off work following your injury? NO / YES
If yes, how long for: _____
3. Will you reduce your other duties/activities following your injury? NO / YES
If yes, how long for: _____
If yes, in what way: _____
4. Will you reduce your driving following your injury? NO / YES
If yes, how long for: _____
If yes, in what way: _____
5. A minor head injury or concussion impairs a person's mental ability to drive a car (e.g. concentrate):
 1. NOT AT ALL
 2. UP TO 24 HOURS AFTER INJURY
 3. UP TO 48 HOURS AFTER INJURY
 4. UP TO 72 HOURS AFTER INJURY
 5. UP TO 1 WEEK AFTER INJURY
 6. UP TO 2 WEEKS AFTER INJURY
 7. LONGER THAN 2 WEEKS AFTER INJURY
6. A minor limb injury (e.g. a broken finger) impairs a person's mental ability to drive a car (e.g. concentrate):
 1. NOT AT ALL
 2. UP TO 24 HOURS AFTER INJURY
 3. UP TO 48 HOURS AFTER INJURY
 4. UP TO 72 HOURS AFTER INJURY
 5. UP TO 1 WEEK AFTER INJURY
 6. UP TO 2 WEEKS AFTER INJURY
 7. LONGER THAN 2 WEEKS AFTER INJURY

References

- [1] Cassidy JD, Carroll LJ, Peloso PM, Borg J, von Holst H, Holm L, Kraus J, Coronado VG. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine* 2004;Supplement 43:28-60.
- [2] McKinlay A, Grace RC, Horwood LJ, Fergusson DM, Ridder EM, Macfarlane MR. Prevalence of traumatic brain injury among children, adolescents and young adults: prospective evidence from a birth cohort. *Brain Injury* 2008;22:175-81.
- [3] Belanger HG, Curtiss G, Demery JA, Lebowitz BK, Vanderploeg RD. Factors moderating neuropsychological outcomes following mild traumatic brain injury: a meta-analysis. *Journal of the International Neuropsychological Society* 2005;11:215-27.
- [4] Preece MHW, Horswill MS, Geffen GM. Driving after concussion: the acute effect of mild traumatic brain injury on drivers' hazard perception. *Neuropsychology* 2010;24:493-503.
- [5] Wells P, Tong S, Sexton B, Grayson G, Jones E. Cohort II: A study of learner and new drivers. London, United Kingdom: Department for Transport; 2008.
- [6] Darby P, Murray W, Raeside R. Applying online fleet driver assessment to help identify, target and reduce occupational road safety risks. *Safety Science* 2009;47:436-42.
- [7] Horswill MS, Anstey KJ, Hatherly CG, Wood J. The crash involvement of older drivers is associated with their hazard perception latencies. *Journal of the International Neuropsychological Society* 2010;16:939-44.
- [8] McKenna FP, Horswill MS. Hazard perception and its relevance for driver licensing. *Journal of the International Association of Traffic and Safety Sciences* 1999;23:26-41.

- [9] Hux K, Schram CD, Goeken T. Misconceptions about brain injury: a survey replication study. *Brain Injury* 2006;20:547-53.
- [10] Linden MA, Crothers IR. Violent, caring, unpredictable: public views on survivors of brain injury. *Archives of Clinical Neuropsychology* 2006;21:763-70.
- [11] McLellan T, Bishop A, McKinlay A. Community attitudes toward individuals with traumatic brain injury. *Journal of the International Neuropsychological Society* 2010;16:705-10.
- [12] Ferrari R, Constantoyannis C, Papadakis N. Cross-sectional study of symptom expectation following minor head injury in Canada and Greece. *Clinical Neurology and Neurosurgery* 2001;103:254-9.
- [13] Mackenzie JA, McMillan TM. Knowledge of post-concussional syndrome in naïve lay-people, general practitioners and people with minor traumatic brain injury. *British Journal of Clinical Psychology* 2005;44:417-24.
- [14] Rosenbaum AM, Arnett PA. The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. *Journal of Clinical and Experimental Neuropsychology* 2010;32:44-55.
- [15] Sye G, Sullivan SJ, McCrory P. High school rugby players' understanding of concussion and return to play guidelines. *British Journal of Sports Medicine* 2006;40:1003-4.
- [16] Teasdale G, Jennett B. Assessment and prognosis of coma after head injury. *Acta Neurochirurgica* 1976;34:45-55.
- [17] Levin HS, O'Donnell VM, Grossman RG. The Galveston Orientation and Amnesia Test: a practical scale to assess cognition after head injury. *Journal of Nervous and Mental Disease* 1979;167:675-84.

- [18] Smith SS, Horswill MS, Chambers B, Wetton M. Hazard perception in novice and experienced drivers: the effects of sleepiness. *Accident Analysis and Prevention* 2009;41:729-33.
- [19] Wechsler D. *Wechsler Adult Intelligence Scale - Revised: Manual*. New York: Psychological Corporation; 1981.
- [20] Sheedy J, Harvey E, Faux S, Geffen G, Shores EA. Emergency department assessment of mild traumatic brain injury and the prediction of postconcussive symptoms: a 3-month prospective study. *Journal of Head Trauma Rehabilitation* 2009;24:333-43.
- [21] Horswill MS, Anstey KJ, Hatherly C, Wood JM, Pachana NA. Older drivers' insight into their hazard perception ability. *Accident Analysis and Prevention* 2011;43:2121-7.
- [22] Weber M, Edwards MG. The effect of brain injury terminology on university athletes' expected outcome from injury, familiarity and actual symptom report. *Brain Injury* 2010;24:1364-71.
- [23] Sheedy J, Geffen G, Donnelly J, Faux S. Emergency department assessment of mild traumatic brain injury and prediction of post-concussion symptoms at one month post injury. *Journal of Clinical and Experimental Neuropsychology* 2006;28:755-72.
- [24] Fung M, Willer B, Moreland D, Leddy JJ. A proposal for an evidenced-based emergency department discharge form for mild traumatic brain injury. *Brain Injury* 2006;20:889-94.
- [25] Snell DL, Surgenor LJ, Hay-Smith EJC, Siegert RJ. A systematic review of psychological treatments for mild traumatic brain injury: an update on the evidence *Journal of Clinical and Experimental Neuropsychology* 2009;31:20-38.

Table 1. Participant characteristics and Recovery Questionnaire responses

	% (n)	<u>M</u> (SD)	Range	Significance test and effect sizes for difference from 'no injury' state
Age (years)		27.53 (8.88)	18 – 59	
Education (years)		13.63 (2.92)	8 – 22	
Gender				
Female	9.9% (8)			
Male	90.1% (73)			
Previous head injury				
No	44.4% (36)			
Yes	55.6% (45)			
Pain		3.92 (2.41)	0 – 10	
Emotionality		3.31 (2.54)	0 – 10	
Post-traumatic amnesia				
No	34.6% (28)			
Yes	65.4% (53)			
Loss of consciousness				
No	49.3% (37)			
Yes	50.7% (38)			
Galveston Orientation and Amnesia Test ^a		85.32 (11.30)	50 – 100	
Hazard Perception Test response time (s) ^a		4.05 (0.88)	2.32 – 6.31	
Digit-symbols correct ^a		52.81 (13.55)	19 – 92	
Recovery questionnaire items				
Estimated recovery time (days) ^b		22.92 (41.32)	0.50 – 183	$z = 7.74, p < 0.001, r = 0.87$
Time off work ^c				$z = -475.10, p < 0.001$
No	46.3% (37)			
Yes	53.8% (43)			
Estimated time off work (days) ^b		5.71 (17.85)	0 – 122	$z = 5.53, p < 0.001, r = 0.63$
Reduce other activities ^c				$z = -538.83, p < 0.001$
No	39.5% (32)			
Yes	60.5% (49)			
Estimated time other activities reduced (days) ^d		12.14 (45.38)	0 – 365.25	$z = 5.60, p < 0.001, r = 0.65$
Reduce driving ^c				$z = -427.71, p < 0.001$
No	51.9% (42)			
Yes	48.1% (39)			
Estimated time driving reduced (days) ^b		7.04 (22.05)	0 – 137.25	$z = 4.87, p < 0.001, r = 0.57$
Minor head injury/concussion's mental effect on driving				
Not at all	3.8% (3)			
≤ 24 hours after injury	36.3% (29)			
≤ 48 hours after injury	26.3% (21)			
≤ 72 hours after injury	15.0% (12)			
≤ 1 week after injury	12.5% (10)			
≤ 2 weeks after injury	3.8% (3)			
> 2 weeks after injury	2.5% (2)			
Minor limb injury's mental effect on driving				
Not at all	35.0% (28)			
≤ 24 hours after injury	18.8% (15)			
≤ 48 hours after injury	11.3% (9)			
≤ 72 hours after injury	3.8% (3)			
≤ 1 week after injury	12.5% (10)			
≤ 2 weeks after injury	5.0% (4)			
> 2 weeks after injury	13.8% (11)			

^aNote that participants with MTBI performed significantly worse on tests of cognitive performance relative to 76 patients with orthopaedic injuries recruited as part of a larger study. Recruitment criteria for the orthopaedic-injured control group has been described previously [4]. Participants with MTBI had significantly lower scores on the Galveston Orientation and Amnesia Test than patients with orthopaedic injuries (M 96.82 SD 5.28), $t(153) = 8.07, p < 0.001$. Participants with MTBI showed significantly slower response times in the Hazard Perception Test than patients with orthopaedic injuries (M 3.77 s SD 0.88), $t(155) = -1.98, p < 0.05$. Participants with MTBI transcribed significantly fewer digit-symbols correctly than patients with orthopaedic injuries (M 57.67 SD 12.95), $t(150) = 2.26, p < 0.05$. As described in the Results section, it was not deemed appropriate to compare the participants with MTBI's performance with an orthopaedic-injured control group regarding return-to-driving intentions.

^bNo injury state was designated 0 days.

^cNo injury state was designated as no intention to reduce the activity.

Table 2. Bivariate correlations between return-to-driving intentions and eight potential predictors

	Reduce driving (no/yes)	Time driving reduced	Age	Education	Gender	Previous head injury	Pain	Emotion- ality	Post- traumatic amnesia	Loss of conscious- ness	Galveston Orientation and Amnesia Test	Hazard Perception Test response time
Time driving reduced	0.35**											
Age	0.08	0.04										
Education	0.02	-0.14	0.07									
Gender	-0.26*	-0.04	-0.31**	-0.15								
Previous head injury	-0.23*	-0.04	-0.16	< 0.01	0.20†							
Pain	0.23*	0.45***	0.05	-0.05	-0.26*	-0.06						
Emotionality	0.08	0.15	-0.13	0.06	-0.07	-0.13	0.37**					
Post-traumatic amnesia	0.18	< -0.01	0.10	-0.14	-0.24*	-0.13	0.26*	0.17				
Loss of consciousness	0.15	0.17	0.05	-0.28*	0.14	0.05	0.15	0.05	0.43***			
Galveston Orientation and Amnesia Test	-0.10	-0.06	0.17	0.08	-0.01	0.11	-0.14	-0.16	-0.40***	-0.42**		
Hazard Perception Test response time	< 0.01	0.13	-0.30**	-0.18	0.04	-0.18	< -0.01	0.24*	0.06	0.14	-0.32**	
Digit-symbols correct	-0.02	-0.19†	-0.25*	0.29**	0.15	0.21†	-0.11	-0.02	-0.06	-0.09	-0.03	-0.25*

† $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 3. Logistic regression analysis for intentions to reduce driving

Predictors	B (SE)	Wald statistic	Odds ratio	95% confidence interval for odds ratio
Previous head injury	-3.99 (1.24)**	10.27	0.019	[0.002, 0.213]
Pain	-0.02 (0.16)	0.02	0.978	[0.721, 1.326]
Previous head injury x Pain (interaction term)	0.68 (0.26)**	6.81	1.983	[1.186, 3.316]
Constant	0.62 (0.71)	0.75	1.849	

Note. $\underline{R}^2 = 0.05$ (Hosmer and Lemeshow), 0.23 (Cox and Snell), 0.31 (Nagelkerke).

* $p < .05$. ** $p < .01$. *** $p < .001$.