Visuospatial Learning in Traumatic Brain Injury: An Examination of Impairments using the Computerised Austin Maze Task

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An important aspect of cognitive functioning that is often impaired following traumatic brain injury (TBI) is visuospatial learning and memory. The Austin Maze task is a measure of visuospatial learning that has a long history in both clinical neuropsychological practice and research, particularly in individuals with TBI. The aim of this study was to evaluate visuospatial learning deficits following TBI using a new computerised version of the Austin Maze task. Twenty-eight individuals with moderate-to-severe TBI were compared to 28 healthy controls on this task, together with alternative neuropsychological measures, including the WAIS-III Digit Symbol and Digit Span subtests, the Trail Making Test, WMS-III Logical Memory, and Rey Osterrieth Complex Figure Test. The results demonstrated that TBI individuals performed significantly more poorly on the Austin Maze task than control participants. The Austin Maze task also demonstrated good convergent and divergent validity with the alternative neuropsychological measures. Thus, the computerised version of the Austin Maze appears to be a sensitive measure that can detect visuospatial learning impairments in individuals with moderate-to-severe TBI. The new computerised version of the task offers much promise in that it is more accessible and easier to administer than the conventional form of the test.

Keywords: Austin Maze, computer version, traumatic brain injury, visual memory, neuropsychological assessment

Introduction

In traumatic brain injury (TBI), the typical pattern of acceleration and deceleration forces within the brain leads to a disruption of neural activity, both within and between the ventrolateral, medial and orbital frontal lobes and the ventromedial temporal lobes (Bigler, 2007; Bigler & Maxwell, 2011; Courville, 1945; Gentry, Godersky, & Thompson, 1988; Hadley et al., 1988). The results of this disruption are long-term impairments in cognitive functioning (Draper & Ponsford, 2008), with one of the most common of these being impairments in learning and memory processes. The learning and memory difficulties experienced are generally non-specific, in that both encoding and retrieval of verbal and visual information can be affected (e.g., Himanen et al., 2006; Shum, Harris, & O'Gorman, 2000). Other areas of cognition that are often affected following TBI include information processing speed and executive function (Draper & Ponsford, 2008; Levin & Kraus, 1994; Ponsford & Kinsella, 1992; Scheid, Walther, Guthke, Preul, & von Cramon, 2006).

With respect to non-verbal measures of learning and memory, one particular measure that has a long history in neuropsychology (McKay, Lee,

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https://doi.org/10.1017/BrImp.2015.3 Published online by Cambridge University Press

Stolwyk, & Ponsford, 2012) and which may be particularly useful to detect impairments in those with a TBI, is the Austin Maze task (Bowden, 1989; Milner, 1965). Used specifically to examine the extent of impairments in complex visuospatial learning, the task requires a person to learn a hidden pathway across a 10 × 10 array of buttons while also adhering to several rules. The task continues until the person has reached a criterion of three correct error-free trials. The Austin Maze task has been used to indicate the extent of impairments in visuospatial learning in both clinical neuropsychological practice and research, with studies consistently demonstrating that the task is a sensitive measure in TBI populations (McDonald, 1993; Shores et al., 1990; Tate & Broe, 1999). Its importance as a measure is also highlighted by the fact that poor performance on the task may be specifically linked to poor psychosocial functioning and reintegration following TBI, particularly in the domains of occupational activities, interpersonal relationships and independent living (Tate & Broe, 1999). Other populations demonstrating sensitivity to this measure have included cigarette smokers (Paul et al., 2006), and those with schizophrenia (Mattson, Berk, & Lucas, 1997), anorexia nervosa (Szmukler et al., 1992), Parkinson's disease (Reid et al., 1989), stroke (Bladin & Chambers, 1993; Donnan, Bladin, Berkovic, Longley, & Saling, 1991), Alzheimer's disease (Fowler, Saling, Conway, Semple, & Louis, 2002), right temporal lobe epilepsy (Hocking et al., 2013; Thomas, 2011) and alcohol dependency (Bowden & McCarter, 1993).

The Austin Maze task was originally developed as a measure of executive function or, more specifically, a measure of planning, error utilisation and regulation ability (Walsh, 1994). It was argued that those with frontal lobe dysfunction would have greater difficulty performing the task due to their inability to eradicate errors across successive trials. However, research in healthy adult samples has indicated that the Austin Maze task is, in fact, predominantly a measure of visuospatial learning rather than a measure of frontal lobe and executive functioning (Crowe et al., 1999). In support of this claim, performance on the Austin Maze task has been associated with performance on alternative tasks of visuospatial functioning, including WAIS-R (Wechsler, 1981) Performance IQ and Block Design, and the Visuospatial Learning Test (Bowden et al., 1992; Crowe et al., 1999; Malec et al., 1992; Tucker, Kinsella, Gawith, & Harrison, 1987). The Austin Maze task appears to have negligible associations with measures of executive function including the Wisconsin Card Sort Test (Heaton, Chelune, Talley, Kay, & Curtiss, 1993) and the Tower of London (Shallice, 1982), and maintains minimal associations with tasks of working memory, including the Brown Peterson Task (Peterson & Peterson, 1959) and the WAIS-R Digit Span Backward (Crowe et al., 1999).

The conventional form of the Austin Maze task was constructed as a small electronic device with buttons and accompanying circuitry. The device required technical expertise for maintenance and it has never been commercially produced. Both these factors are argued to have contributed to its declining use in research and clinical settings over the past 20 years (McKay et al., 2012). However, a new computerised adaptation of the Austin Maze task is now available (Bray & McDonald, 2010), making the task more accessible to both clinicians and researchers alike. Like the traditional version, the new computerised version uses the traditional Milner pathway (Milner, 1965).

A recent study by McKay, Lee, Stolwyk and Ponsford (2012) found that the new computerised version of the Austin Maze task produced results that were comparable to results on the conventional form of the test in a sample of young, healthy university and community participants aged between 18 and 27 years. The study further validated the applicability of the existing norms for use with the new computerised version in this age group. In a related study using this same sample of participants, Stolwyk, Lee, McKay and Ponsford (2013) examined the construct validity of the new computerised Austin Maze task. Their findings were largely consistent with the findings of Crowe et al. (1999) noted above, which demonstrated associations between the Austin Maze task and tasks of visuospatial ability, but not tasks of executive functioning. However, while no unique relationship between working memory (measured using the WAIS-IV Digit Backward task) and the Austin Maze task performance was established in this study, the direct relationship (i.e., zero-order correlation) between the two measures was not examined.

To date, the computerised Austin Maze task has not been examined in a clinical sample. As such, it is not known whether the new version of the task remains sensitive as a measure of visuospatial learning impairments in individuals with TBI. The primary purpose of this current study, therefore, is to validate the computerised Austin Maze task for use in an adult TBI sample. It is specifically hypothesised that individuals with a TBI will perform more poorly on the Austin Maze task compared to a demographically matched control group. It is further hypothesised that the task will demonstrate reasonable levels of convergent and divergent validity with alternative cognitive tasks. Based on the

https://doi.org/10.1017/BrImp.2015.3 Published online by Cambridge University Press

findings of previous research already discussed, it is specifically expected that the Austin Maze task will be highly associated with alternative measures of visuospatial learning and visuospatial functioning, will not be associated with tasks of executive function, and will show minimal association with tasks of working memory. It is further hypothesised that because the Austin Maze task is domain specific, in that it is a measure of visuospatial learning ability, performance on the task will not be related to tasks of verbal learning and memory.

Method

Participants

Ethics approval for this research was obtained from the Human Research Ethics Committee of the University of New South Wales. Participants included 28 adults (20 males) with a mean age of 44.93 years ($SD = 14.11$; range 22–69) and 12.71 mean years of education ($SD = 2.31$; range 9–17), who were recruited from the outpatient records of three brain injury units across metropolitan Sydney. All participants met the following inclusion criteria: they had sustained a moderate-to-severe TBI resulting in a period of post-traumatic amnesia (PTA) of at least 1 day, were discharged from hospital and living in the community, and had English as their primary spoken language. Participants were excluded if they had: uncorrected hearing or vision loss, a current diagnosed drug and/or alcohol addiction, active psychosis or psychiatric condition, dementia or other neurodegenerative disease, aphasia, agnosia or profound amnesia.

The mean PTA length was 56.41 days ($SD = 49.85$; range 3–189). Time post injury at testing ranged from 3 to 33 years ($M = 12.11$ years, $SD = 8.48$). Causes of TBI included motor vehicle or motor bike accidents ($n = 16$), falls ($n = 7$), sporting accidents ($n = 1$) and assault ($n = 4$). Computerised axial tomography (CT) scans indicated that participants' injuries were right hemisphere-focused ($n = 6$), left hemisphere-focused ($n = 4$) or bilateral ($n = 12$). For the remaining participants, scan readings did not specify which hemisphere contained the injury ($n = 3$), or were unavailable ($n = 3$). It should be noted that these scans were conducted for clinical purposes and are unlikely to reflect the true extent of pathology.

A control group of 28 adults without a prior history of head injury were recruited from the general community via advertisements placed online and in local community newspapers. Each control participant was matched to a TBI participant on the basis of being of the same sex, a similar age, and similar educational attainment. The TBI and control groups did not differ significantly with respect to sex distribution, age or years of education ($p = 1.00$, .906 and .089, respectively).

Measures

Austin Maze – computerised version (Bray & McDonald, 2010). This task requires participants to learn through trial and error, a 'secret' pathway within a 10 × 10 array of square blocks. The pathway starts in the bottom left-hand corner and concludes in the top right-hand corner of the computer screen. On each successive trial, participants are required to use the mouse to move in a left/right or up/down direction (diagonal moves are not permitted). The block will turn green briefly when the trial is correct and red if the trial is incorrect. The participant returns to the last correct block following an incorrect trial before making a proceeding move. Upon completion of each trial, information containing details of the number of errors at the end of each trial, and the last correct move, remain highlighted on the screen. A discontinue criterion of three errorless trials within 20 trials was applied. The conventional Milner (1965) pathway was also applied.

Other neuropsychological tests. All participants were assessed for:

(1) Premorbid IQ – Wechsler Test of Adult Reading (WTAR; Psychological Corporation, 2001), a test requiring participants to read a list of words with irregular pronunciations (estimated IQ based on errors).

(2) Processing speed – Digit Symbol from the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997a), a test requiring participants to write down corresponding symbols as fast as possible (scaled scores); and Trail Making Test Part A (TMT A) (Reitan, 1992), a test requiring participants to sequentially connect 25 numbers as quickly as possible (time to complete). Processing speed was included in this study as it is not clear from previous studies the extent to which this cognitive domain may be related to Austin Maze task performance.

(3) Verbal memory – Logical Memory I and II (LM I and LM II) from the Wechsler Memory Scale – Third Edition (WMS-III; Wechsler, 1997b), which requires participants to recall verbally presented stories both immediately and following a delay (scaled scores).

(4) Working memory – WAIS-III Digit Span, a test requiring participants to immediately

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recall verbally presented numbers (forwards and backwards; scaled scores).

(5) Visual memory – Rey Osterrieth Complex Figure (ROCFT; Rey, 1941), a test requiring participants to copy a complex geometrical figure and recall it following a 30-minute delay (Taylor's scoring criteria applied; Strauss, Sherman, & Spreen, 2006).

(6) Perceptual organisation and planning – ROCFT copy trial.

(7) Flexibility – TMT Part B (TMT B) (Reitan, 1992), a test requiring participants to sequentially connect alternating numbers and letters as quickly as possible (time to complete). The difference score (TMT Part B minus Part A) was used to control for the effects of processing speed.

Working memory, flexibility, perceptual organisation and planning are elements of executive functioning.

Procedure

After obtaining informed consent from participants, demographic information was collected and the neuropsychological tests were completed. For the Austin Maze task, participants first undertook a practice trial prior to completing the actual task. Scores to evaluate performance on this task included: (1) total cumulative errors for the 20 trials (Total Errors); (2) cumulative errors for the first 10 trials (Errors to 10 Trials); (3) the number of trials undertaken until the discontinue criterion is reached (Trials to Criterion); those individuals who did not meet the criterion within 20 trials were assigned a maximum score of 20 to enable group comparisons; and (4) the total time taken to complete all task trials (Completion Time).

Statistical Analyses

Data were analysed using IBM SPSS (Version 22; IBM Corporation, 2013). To compare the performance of TBI and control-group participants on the Austin Maze task and other background neuropsychological tests, *t*-tests were calculated. A significance value of $p < .001$ (criteria of 3.29 *z*-scores) was used to formally detect outliers and assess normality (Tabachnick & Fidell, 2013). Only one outlier was detected on the Errors to 10 Trials variables. Moderate positively skewed distributions were detected on the Total Errors, Errors to 10 Trials, Completion Time and TMT B scores. Inspection of histograms also indicated a bi-modal distribution for the Trials to Criterion variable, owing to the relative large number of participants (68% of TBI and 43% of control participants) failing to reach the criterion by trial 20. Homogeneity of variance was violated in the Total Errors, Trials to Criterion and TMT A variables. As a result of these assumption violations, non-parametric Mann–Whitney *U*-tests were performed in addition to parametric *t*-tests. Since the results of the non-parametric and parametric analyses did not differ, for simplicity and ease of interpretation only the results of the parametric *t*-test are reported. Cohen's *d* effect sizes for the group differences are also reported. A logistic regression was performed to ascertain whether the overall completion rate differed between TBI and control participants. To assess Austin Maze task construct validity, correlations were calculated with alternative standard neuropsychological tests. Variables were again assessed for outliers, normality and linearity. Variables with moderate positively skewed distributions included Total Errors, Errors to Trial 10, Trials to Criterion, Completion Time and TMT B. Inspection of bivariate scatterplots indicated obvious non-linear relationships in all Trials to Criterion analyses. Due to the extent of assumption violations for the correlation analyses, Spearman rank-order correlations were performed. Although group differences in premorbid intelligence (WTAR) were found, this variable was not significantly correlated with the various Austin Maze task variables ($r = .13$ to $-.25$, ns), nor did its inclusion as a covariate alter the results of any comparison analysis. Premorbid intelligence was therefore not controlled for in this study. There was also a trend for higher levels of education in the control group. While this variable was significantly correlated with only one Austin Maze measure, the Trials to Criterion variable ($r = -.30$, $p = .026$), its inclusion as a covariate did not alter the results of the comparison analysis. As such, education was also not controlled for in this study.

Results

Background Neuropsychological Tests

Descriptive data and comparison statistics for performance in standard neuropsychological test scores are summarised in Table 1. The TBI group performed significantly more poorly than the control group on most neuropsychological tests, including the Digit Symbol, TMT A and B, Digit Span, and the ROCF Delay. Consistent with other research demonstrating that such measures are affected by injury severity (Mathias, Bowden, Bigler, & Rosenfeld, 2007; Morris, Wilson, Dunn, & Teasdale, 2005), TBI participants also performed significantly more poorly on the WTAR. Significance

https://doi.org/10.1017/BrImp.2015.3 Published online by Cambridge University Press

TABLE 1
Descriptive Statistics of Standard Neuropsychological Tests by Group with *t*-test Comparisons

	TBI ($n = 28$)			Control ($n = 28$)					
Test	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*-value	*d*	Sig.
WTAR (Estimated IQ)	28	105.82	11.97	28	116.00	9.73	3.49	.93	.001
Digit Symbol WAIS-III	27	7.70	2.77	25	10.56	2.61	3.82	1.06	<.001
TMT A (time in sec)	28	38.82	16.85	25	28.84	8.29	2.68	.75	.010
TMT B (time in sec)	28	88.36	38.08	25	63.76	19.19	2.91	.82	.005
TMT B − A	28	49.54	31.16	25	34.92	17.87	2.06	.58	.044
LM I WMS-III SS	25	9.52	3.44	23	11.04	2.84	1.67	.48	.103
LM II WMS-III SS	25	10.24	3.56	23	11.96	2.36	1.95	.57	.057
Digit Span WAIS-III SS	28	9.53	2.97	25	11.48	2.80	2.44	.68	.018
ROCF Copy	7	29.86	3.64	18	31.72	1.96	1.67	.64	.108
ROCF Delay	7	13.64	9.15	18	20.44	5.38	2.32	.91	.029

Results of two-tailed *t*-test comparison analyses are shown. Cohen's *d* is the reported effect size. LM, Logical Memory; SS, scaled score; TMT, Trail Making Test; WAIS, Wechsler Adult Intelligence Scale; WMS, Wechsler Memory Scale; WTAR, Wechsler Test of Adult Reading. Except where indicated (i.e., SS or time in sec), raw scores are provided in the table.

was approached in the Logical Memory II (delayed recall) test ($p = .057$). No differences between groups were detected in Logical Memory I (immediate recall) and the ROCFT copy.

Austin Maze Task Comparison Analyses

Descriptive data and comparison statistics for performance in the Austin Maze task variables are summarised in Table 2. The TBI group performed significantly more poorly than the control group on all maze task variables, including Total Errors, Errors to Trial 10, Trials to Criterion and Completion Time. Results from a logistic regression analysis indicated a trend toward a lower completion rate in TBI ($n = 9/28$) than in control participants ($n = 16/28$) [$B = .29$, Wald $\chi^2(1) = 3.58$, $p = .058$].

Austin Maze Task Correlations with Other Tests

Spearman rank-order correlations examining the relationship between the various Austin Maze task measures and alternative standard neuropsychological tests are shown in Table 3. All Austin Maze task measures were significantly and moderately negatively correlated with the WAIS-III Digit Symbol and Digit Span subtests, significantly and highly positively correlated with TMT A and B, and significantly and highly negatively correlated with the ROCFT Delay task. No Austin Maze task measure was significantly correlated with the WMS-III LM I and LM II or ROCFT Copy tasks.

Discussion

The aim of this study was to evaluate visuospatial learning in an adult TBI population using the recently developed computerised version of the Austin Maze task (Bray & McDonald, 2010). Confirming our primary hypothesis, when compared to a healthy, adult, demographically matched control group, individuals with moderate-to-severe TBI performed more poorly on all Austin Maze task measures. This included the number of total cumulative errors made, the number of cumulative errors made in the first 10 trials, the number of trials required to reach criterion and overall task completion time. Although Austin Maze task completion rates (i.e., criterion reached within 20 trials) were not significant between groups, a trend ($p = .058$) was apparent, with lower completion rates in individuals with TBI. These results are consistent with prior studies using the conventional Austin Maze task, which indicate that TBI individuals are significantly impaired on the task (McDonald, 1993; Shores et al., 1990; Tate & Broe, 1999). Despite the (albeit subtle) differences between the conventional and computerised versions of the task (e.g., the absence of auditory feedback and the provision of visual feedback in the computerised version), these results provide further evidence of the equivalency between the two versions of the task, which was recently demonstrated in a sample of healthy young participants through direct comparison of the two task versions (McKay et al., 2012).

Supporting our secondary hypothesis, the results of this study demonstrate that the Austin Maze task has strong convergent and divergent

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TABLE 2

Descriptive Statistics of the Austin Maze Task by Group with *t*-test Comparisons

	TBI ($n = 28$)		Control ($n = 28$)				
Test	*M*	*SD*	*M*	*SD*	*t*-value	*d*	Sig.
Total Errors	141.75	115.15	63.14	53.68	3.27	.88	<.001
Errors to 10 Trials	91.36	61.12	49.79	38.09	3.05	.82	.003
Trials to Criterion	18.00	3.41	14.25	5.49	3.07	.82	.003
Completion Time (min)	20.69	13.14	10.51	4.71	3.86	1.03	<.001

Results of two-tailed *t*-test comparison analyses are shown. Cohen's *d* is the reported effect size.

TABLE 3

Spearman Rank-Order Correlations between Austin Maze Task Measures and Alternative Neuropsychological Tests

	WAIS-III Digit Symbol	WAIS-III Digit Span	TMT A	TMT B	TMT B − A	WMS-III LM I	WMS-III LM II	ROCFT Copy	ROCFT Delay
Total Errors	−.366**	−.407**	.568***	.731***	.552***	−.169	−.174	−.202	−.805***
Errors to Trial 10	−.327*	−.436***	.549***	.703***	.506***	−.146	−.169	−.198	−.769***
Trials to Criterion	−.464***	−.332*	.551***	.720***	.557***	−.112	−.106	−.394	−.740***
Completion Time	−.314*	−.391**	.426***	.613***	.442***	−.009	.015	−.122	−.576**

LM, Logical Memory; ROCFT, Rey Osterrieth Complex Figure Test; TMT, Trail Making Test; WAIS, Wechsler Adult Intelligence Scale; WMS, Wechsler Memory Scale.
*$p < .05$; **$p < .01$;***$p < .001$.

validity with alternative standard neuropsychological measures. Most notably, while performance on the various Austin Maze task measures was divergent from performance on verbal-based learning and memory tasks (WMS-III LM I and LM II), they were highly convergent with ROCFT Delay scores, a commonly used index of long-term memory of complex visual information (Hocking et al., 2013; Shin, Park, Park, Seol, & Kwon, 2006). Specifically, poor recall scores on this task were associated with poor Austin Maze performance. Scores on the various Austin Maze task measures were not convergent with ROCFT Copy scores, a finding that appears inconsistent with previous studies in healthy adults, which demonstrate associations between the Austin Maze task and alternative tasks of visuospatial ability, including WAIS-R Performance IQ and WAIS-R Block Design (Bowden et al., 1992; Stolwyk et al., 2013; Tucker et al., 1987). However, since the ROCFT Copy task primarily involves not only abilities in visuospatial constructional praxis, but also executive function planning and organisation abilities (Kuehn & Snow, 1992; Shin et al., 2006), this finding is not that surprising. It also echoes independent research showing negligible associations between the conventional Austin Maze task and both verbal learning and ROCFT copying tasks in patients with unilateral temporal lobe epilepsy (Hocking et al., 2013). While the Austin Maze task was originally intended as a measure of planning ability (Walsh, 1994), our results suggest that it is not sensitive to planning (as measured by the ROCFT). This is consistent with previous studies, insofar as they demonstrate that there is little association between the Austin Maze task and measures of executive function, including planning and abstraction (Heaton et al., 1993; Shallice, 1982).

Our findings also indicate that performance on the Austin Maze task was associated with working memory (WAIS-III Digit Span). In their study of university students, Crowe et al. (1999) found some association between the Austin Maze task and tasks of working memory (Brown-Peterson task and WAIS-R Digit Span Backward). However, this association was minimal and it appeared to be mediated by other visuospatial measures used in the study (WAIS-R Block Design and the Visual Spatial Learning Test). The moderate association found in our study indicates that the Austin Maze task may involve more working memory function than that indicated by Crowe et al. (1999). Indeed, given that the Austin Maze task does require maintenance of spatial information in mind in order to perform the next trial correctly, it seems logical that there would be some involvement of

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working memory in the task. The extent to which other visuospatial measures may mediate the relationship between Austin Maze task performance and working memory, however, was not specifically examined in this current study.

Performance on the Austin Maze task was also moderately associated with measures of information processing speed (WAIS-III Digit Symbol and TMT A), and divided attention and flexibility (TMT difference score; Johnco, Wuthrich, & Rapee, 2013; Kortte, Horner, & Windham, 2002). Although an examination of the relationship between the Austin Maze task and measures of flexibility has not been reported previously in the published research, both performance on the Austin Maze task and TMT B have been found to be conjointly impaired in patients with low-weight anorexia nervosa (Szmukler et al., 1992). The association between the two measures may reflect the self-monitoring requirements of both tasks. Specifically, both tasks require an individual to remember what they did on a previous trial in order to inform the best move for the next trial. That is, there is a requirement to utilise feedback information from both errors and correct trials in order to regulate performance.

Overall, our results suggest that impaired Austin Maze task performance reflects disorder in some, but not all, types of executive abilities in a clinical TBI sample. That is, while Austin Maze performance is related to working memory and flexibility, it is not related to organisation and planning ability. This is not unexpected, given that executive functioning is not a unitary concept but, rather, a collection of 'higher-order' processes that co-ordinate several sub-processes in order to achieve a particular goal (Elliott, 2003). However, as only a limited set of neuropsychological tests were used to index executive processes, future research should examine the involvement of various executive processes in Austin Maze performance in detail, and determine whether similar patterns of mediation exist across both clinical and control groups.

An examination of the extent of convergence with other tasks measuring visuospatial ability, such as the WAIS-IV Block Design task, and the extent of divergence with additional measures of executive functioning, such as the Tower of London task or Wisconsin Card Sort Test, would also have been beneficial to further establish the validity of the Austin Maze task. How the computerised version of the Austin Maze task performs with repeated testing in both TBI and healthy populations also remains unknown. In a previous study using the conventional Austin Maze task, Tucker et al. (1987) demonstrated significant practice effects and some test–retest reliability over a 1-month period for trials to criterion ($r = .56$) and total cumulative errors ($r = .79$) in a sample of healthy young adults. It is important that this retest information be established in future research so that the clinical change parameters of the task can be established. It is also important to note that the current results pertain only to those with a moderate-to-severe TBI. As such, the extent to which individuals who have sustained a mild TBI may be impaired on the Austin Maze task needs to be examined in future research.

In summary, the present research indicates that the Bray and McDonald (2010) computerised version of the Austin Maze task is able to discriminate the performance of moderate-to-severely impaired individuals with TBI from that of healthy individuals. The task, therefore, is a useful measure to detect impairments in visuospatial learning following TBI. The Austin Maze measure also demonstrates reasonable convergent and divergent validity with other neuropsychological measures. Most notable is the strong association between performance on the Austin Maze task and the ROCFT following a delay, an alternative measure of visuospatial memory. Given the ease of use and greater accessibility over its conventional counterpart, and its history in the assessment of visuospatial learning in TBI individuals, the computerised version of the Austin Maze task continues to be a useful tool for the assessment of visuospatial learning ability in both clinical neuropsychological practice and research.

Acknowledgement

This research was supported by the Australian Research Council with an ARC Discovery Project Grant (number DP09886689). We are grateful to staff of the Royal Ryde Rehabilitation Centre, who assisted with recruitment. We are particularly grateful to the people with traumatic brain injuries and our control participants who gave willingly of their time to assist this research.

Disclosure Statement

There are no conflicts of interest to declare.

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