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Psychosocial adjustment after traumatic brain injury: what are the important variables?

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ABSTRACT

Background. The common legacy of severe degrees of traumatic brain injury is varying degrees and types of impairments, which impact significantly upon the individual's resumption of pre-morbid psychosocial roles. Yet there are few data to indicate the relative contribution of these and other non-injury related variables.

Methods. Seventy individuals with varying levels of disability after severe traumatic brain injury were examined neurologically and neuropsychologically, on average at 6 years post-trauma. A range of biographical, injury, impairment and psychological variables were examined with multiple regression analyses to identify those that contributed to successful psychosocial reintegration.

Results. Severity of injury and impairments, along with chronicity and level of self-esteem were significant predictors of psychosocial adjustment. Further analyses revealed that within the neuropsychological domain, the variable measuring behavioural regulation of abilities was the most significant. Examination of specific domains of psychosocial functioning (occupational activities, interpersonal relationships and independent living skills) revealed different patterns of significant predictor variables, in addition to indices of the severity of initial injury: neurophysical impairments and memory functioning predicted successful occupational activities; chronicity, cognitive speed and behavioural regulation predicted success in interpersonal relationships; and neurophysical impairments, behavioural regulation and memory functioning predicted independent living skills.

Conclusions. These results reinforce the overriding importance of injury severity and neurological factors (both neurophysical as well as neuropsychological) in predicting psychosocial adjustment after traumatic brain injury. Support for the contribution of non-neurological factors was also found.

INTRODUCTION

It is well established that impairments in both neurophysical and neuropsychological functioning after severe degrees of traumatic brain injury (TBI) are extremely common (Jennett *et al.* 1981; Tate *et al.* 1989*a*; Masson *et al.* 1996). Similarly, a ubiquitous finding is that many such individuals experience disability and/or handicap affecting their everyday functioning, particularly in the psychosocial domain (Thomsen, 1984; Tate *et al.* 1989*b*; McLean *et al.* 1993). Less clear, however, are the relationships among these sequelae of the injury. Moreover, the contributions of other relevant variables need to be considered. Lishman (1973) made a distinction between direct and indirect effects of the injury and drew attention to the influence of non-neurological factors: response to intellectual impairment, environmental factors, compensation and litigation, emotional impact and repercussions of the injury, pre-morbid per-

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Table 1. *Variables used in multivariate studies of psychosocial outcome after TBI*

	Klonoff *et al.* (1986)	Vogenthaler *et al.* (1989)	Ezrachi *et al.* (1991)	Ruff *et al.* (1993)	Vilkki *et al.* (1994)	Heinemann *et al.* (1995)	Ip *et al.* (1995)	Ponsford *et al.* (1995)	Bowman (1996)
Final *N*…	71	75	59	53	41–45	758	45	74	118–347
Outcome variable/s	Quality of life (e.g. KAS, SIP)	Work Living arrangements Hours of care	Work	Work	Work Social activity Impulsiveness Withdrawal	'Impairment' ADL CIQ Satisfaction ratings	Work	Work	[1]Work [2]Daily activity PPI
Final number of predictor variables	16	10	27	7	8	4–9	8	4	37
Demographic	4	7	3	1	2	3	3	1	6
Age	+	+	+	+	+	+	+	+	+[1*]
Gender	+	+				+			+[1*]
Education	+	+	+		+	+			
Work status pre-morbid		+							+
Work status post-trauma									+[1*]
Time between injury and job									+[1*]
Marital status	+	+					+		
Living arrangements		+							
Hx alcohol							+		
Pre-morbid adjustment		+	+						
Insurance									+
Injury	6	2	2	1	1	2	0	2	4
GCS	+	+						+	
Days coma			+	+		(+)			
Days PTA					+			+	
PTA/coma									+
Anaesthesia									+
Time in rehabilitation/services used		+							+[1*2*]
Chronicity	+		+			+			+
Multiple trauma	+								
Other injuries	+								
CT results	+								
Alcohol at injury	+								

Motor-sensory	1	0	0	0	0	0	0	0	1
Composite measures									+
Seizures	+								
Cognition	5 factors	0	12 factors	5 tests	2 factors	0	5 tests	0	14 tests
Intelligence			+ (2)	+ (2 subtests BD, Voc)	'Operational Resources'		WAIS-R PIQ		7 WAIS-R subtests. BD[1*] Sims[2*]
Memory	+		+				+		WMS/R[1*] WMS/R[2*] TPT
Mental speed				+			+ (×2)		+
Attention			+ (×4)	+					+
Language	+								
Executive	+		+ (×2)	+	'Mental Programming'				CatT[2*] and others
Manual dexterity	+		+	+			+		
Other cognitive	Laterality		Visual process Academic skills						TPT
Psychosocial	0	1 Social support	6 'Group process measures' e.g. self-esteem (×4) Staff ratings (×2)	0	3 NRS (×3 factors)	3 (CIQ×3 factors)	0	0	12 factors MMPI K[1*2*], 3[2*], 9[2*]
Other			BCI (4 factors)					DRS	

GCS, Glasgow Coma Scale; PTA, post-traumatic amnesia; CT, computerized tomography; KAS, Katz Adjustment Scale; SIP, Sickness Impact Profile; ADL, activities of daily living; CIQ, Community Integration Questionnaire; PPI, Percentage Permanent Impairment; BCI, Behavioral Competence Index; NRS, Neurobehavioral Rating Scale; WAIS-R PIQ, Wechsler Adult Intelligence Scale-Revised Performance IQ; DRS, Disability Rating Scale; BD, WAIS-R Block Design; Vocab, WAIS-R Vocabulary; TPT, Tactual Performance Test; WMS/R, Wechsler Memory Scale/Revised; CatT, Category Test; MMPI, Minnesota Multiphasic Personality Inventory.

Superscripts attached to variables in Bowman's (1996) study refer to statistically significant variables in analyses for RTW[1] or Daily Activity[2] (refer to text).

sonality and mental constitution. In fact, his conclusion was that brain damage factors (such as the extent and location of brain damage) contribute only about 1/15 part to psychiatric disability (defined as any of intellectual, emotional or behavioural disturbance).

Interest in these non-neurological or indirect causes of morbidity after TBI has resurfaced with recent formulations arising from the literature on stress and coping (Lazarus & Folkman, 1984). In applying this model to the TBI group, Kendall & Terry (1996) suggest that psychosocial adjustment is affected by a range of antecedent variables, not only indices of injury and impairments, but also other factors similar to those suggested by Lishman (1973): pre-morbid psychosocial variables, personal and environmental resources, and situational factors. Additionally, the model proposes that a second group of factors mediate the effects of antecedent variables on outcome, these being the cognitive appraisals of the individual and coping strategies to deal with stressful events. In Lishman's terms, the individual's response to intellectual impairment and the emotional impact and emotional repercussions of the injury represent mediators. Similar models have been described by Moore & Stambrook (1995) and Godfrey *et al.* (1996).

In the context of adapting the Lazarus and Folkman framework to TBI, Kendall & Terry (1996) provide a comprehensive review of the outcome literature. They were not able to identify those variables that exert most influence on psychosocial adjustment, however, because many of the studies available at the time of their review were either descriptive in nature or used bivariate methods of analyses. Although a number of relevant reports with multivariate designs are now available, it is difficult to compare findings. In part, this is due to methodological differences that inevitably occur with these particular designs, such as those foreshadowed by Brooks (1989) pertaining to selection of subjects, outcome and predictor variables, measuring instruments, frequency and methods of data collection, cases : variables ratio and so forth. Table 1 demonstrates the magnitude of the methodological differences among a number of recent reports.

The thrust of contemporary empirical work is prediction of functional psychosocial outcomes, for example, return to work (RTW) and performance of everyday and social activities. This approach is seen to be of greater clinical relevance than studies predicting performance on other tests, such as that of Smith-Knapp *et al.* (1996), of which Johnstone (1996) was critical. Few studies, however, have included a comprehensive range of measures, sampling those domains highlighted by Lishman (1973) and Kendall & Terry (1996). An exception is Bowman's (1996) investigation which found that in predicting RTW, demographic and neuropsychological variables accounted for greater amounts of variance (27% and 21% respectively) than did biomedical or emotional variables (2% and 7% respectively). The final equation accounted for a relatively small amount of the variance (34%) (with the significant variables indicated by an asterisk in Table 1). Different predictor variables contributed to social activity, but they were also less powerful than those for RTW, with the final equation only accounting for 19·5% of the variance. As with the results for RTW, neuropsychological variables accounted for a greater proportion of the variance (10%) in comparison with biomedical or demographic variables (6% and 0% respectively). The emotional domain, however, contributed most variance (15%).

Many studies accord a central role to neuropsychological factors as predictors of psychosocial adjustment. It is clear, however, that some neuropsychological variables are more important than others. Vilkki *et al.* (1994) found that variables examining executive abilities were more predictive of successful psychosocial reintegration than traditional cognitive variables from intelligence and memory tests. The usual cause of impairments of executive abilities is frontal systems dysfunction, and the anterior regions of the brain commonly take the brunt of damage after TBI (Adams *et al.* 1985). In addition to their role in higher cognitive functions, executive abilities are also involved in behavioural regulation, with impairments resulting in disinhibition of emotional controls and impoverished drive (Luria, 1969, 1973; Blumer & Benson, 1975). Given the frequency with which individuals with TBI and their relatives report changes in behaviours implicating frontal systems dysfunction (McKinlay *et al.* 1981; van Zomeren & van den Burg, 1985; Brooks *et al.* 1986), these types of impairments should be

included as potential predictors of successful reintegration. Recent developments in the more objective evaluation of these frontally-mediated disturbances in regulatory behaviour have used test-taking variables from the neuropsychological examination (Miller, 1985; Miller & Milner, 1985; Crowe, 1992; Burgess & Shallice, 1996; Tate, 1998).

Methodological limitations are encountered in a number of studies using multivariate designs. A frequent focus is RTW, but although important, this outcome variable comprises only one aspect of psychosocial adjustment. There is, therefore, a need to broaden the types of psychosocial outcome variables examined in a single sample of severely injured participants in order to determine whether different predictor variables contribute to different types of outcomes, as was found in Bowman's (1996) sample of less severely disabled subjects. Moreover, in examining neuropsychological variables, studies invariably restrict inclusion to cognitive variables, and no report to date has examined those types of neuropsychological sequelae which relatives report are most stressful, changes in behaviour. Accordingly, the present study aimed to identify from a representative selection of biographical, injury, impairment and psychological measures, those variables contributing to successful psychosocial outcomes in a group of people surviving severe degrees of TBI.

METHOD

Participants

The clinical sample comprised members of a consecutive series of the first 100 patients with blunt head injury admitted to a regional brain injury rehabilitation unit at Lidcombe Hospital. Admission criteria to the unit comprised age (15 to 45 years at the time of injury), residence in the geographical catchment area served by the unit (at that time the Western Metropolitan Health Region of Sydney, population approximately 1 million residents), and recent TBI of sufficient severity to require rehabilitation. Participants were examined in the outcome stage, after recovery had plateaued, ranging from 3·4 to 9·7 years post-trauma. Eighty-seven individuals in the series were available for follow-up (seven were deceased and six were unable to be located), but 17 participants had missing data values on a number of measures mainly due to motor-sensory deficits. The data from these subjects were excluded from statistical analysis, leaving a final sample size of 70 participants.

Forty healthy siblings of the individuals with TBI, matched on age, gender and years of schooling, acted as control subjects for the neuropsychological component of the study. Additionally, a close relative of each TBI participant was interviewed with respect to psychosocial reintegration of the brain-injured person.

Materials

A range of biographical, injury, impairment and psychological measures were selected as initial predictor variables. Five biographical variables comprised age at injury, gender, years of schooling, occupational status at the time of injury, and history of pre-morbid antisocial activities. Occupational status was measured using Daniel's (1983) scale, comprising ratings (range: from 1·2 to 6·9) for 162 occupations. Higher scores indicate lower prestige occupations. Antisocial activities were defined as an official record of teenage delinquency, conviction for criminal offences and/or substance dependency as reported by a close relative. Three injury variables were duration of unresponsiveness to verbal command, length of post-traumatic amnesia, and time post-trauma or chronicity. Two variables, perception of degree of disability and level of self-esteem, sampled appraisals of the brain-injured people. Participants were asked the extent to which they felt handicapped or disabled as a result of the injury, and responded on a Likert-type scale, from 1 = 'not at all' to 5 = 'a lot'. Self-esteem was measured with the Coopersmith Self-Esteem Inventory (Coopersmith, 1981), a 25-item questionnaire with forced-choice format. Scores range from 0 to 100, with higher scores indicative of higher levels of self-esteem.

Two impairment scales, previously described in Tate *et al.* (1989*a*), were derived from measures taken from the neurological and neuropsychological examinations. Degree of neurophysical impairment was based on four variables (weakness, spasticity, incoordination and gait). Each variable was assessed in the standard manner using the scale: 1 = normal, 2 = mild, 3 = moderate, 4 = severe. Neuro-

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physical outcome was classified at one of four levels (No Impairment, Mild, Moderate or Severe Impairment).

Neuropsychological impairment was measured with seven variables in four domains frequently impaired after blunt head injury: memory, cognitive speed, concept formation and behavioural regulation of cognitive abilities. Tests comprised: the Selective Reminding Test (Buschke & Fuld, 1974) for verbal learning; Austin Maze (Walsh, 1991) for non-verbal learning; and Tower of London (Shallice, 1982) for cognitive speed, using the score from planning time for the easy items. Verbal concept formation was assessed with the Wisconsin Card Sorting Test (Heaton *et al*. 1993) and non-verbal concept formation with the Booklet Category Test (DeFilippis & McCampbell, 1979). Two aspects of behavioural regulation of cognitive abilities were examined following Milner's (1964) method: disorder of control using the score for rule breaking on the first five trials of the Austin Maze; and disorder of drive using the score for perseverative errors on the Wisconsin Card Sorting Test. Test results of the matched control group provided the basis for classification of overall neuropsychological outcome at one of four levels (No Impairment, Mild, Moderate or Severe Impairment). Presence or absence of impairment in each of the four domains was also determined with reference to the control group, impairment being defined as a score beyond two standard deviations of the mean score of the control group on the variable/s representing the particular cognitive domain.

The outcome variables comprised psychosocial reintegration, both for the overall level and three domains: occupational activities, interpersonal relationships and independent living skills. Each of these areas is sampled in the Psychosocial Disability Scale described in Tate *et al*. (1989*b*). On the basis of the results of interviews with the close relative of the person with brain injury, consensus ratings from two treating clinicians were used to classify subjects into one of three levels of functioning in each area. Amalgamating the three areas enabled classification of overall level of psychosocial reintegration at one of three levels (Good, Substantially Limited and Poor Psychosocial Reintegration). The stability of the scale over a 6-week period was $r_s = 0{\cdot}87$ (cited in Tate *et al*. 1996), and it has a statistically significant association with Jennett & Bond's (1975) Glasgow Outcome Scale (C = 0·65) (Tate *et al*. 1989*b*). For this study, the results were analysed using a dichotomized variable for both overall psychosocial reintegration and each of the three domains, Good *versus* the combined categories of Substantially Limited and Poor. The combined categories were labelled Restricted.

RESULTS

The demographic characteristics of the TBI participants were consistent with the epidemiological features of this clinical population, both in Australia and elsewhere (Kraus *et al*. 1984; Jennett, 1996; Tate *et al*. 1998). Average age at the time of injury was 23·39 years (S.D. 7·22), with 9·40 years of schooling (S.D. 1·21), and the ratio of males to females was 3:1, with 52 males and 18 females. Semi-skilled and unskilled occupations were the most frequent occupational groupings (51·4%) and 11·4% were unemployed at the time of injury. Cause of injury for most participants (89%) was road traffic accident.

Average duration of PTA was 65·26 days (S.D. 51·01), with PTA in excess of 1 week occurring in all but two people and 81% having duration of PTA for 1 month or longer, indicative of extremely severe TBI. In terms of overall outcome on the Glasgow Outcome Scale at the time of follow-up, 63% were classified as Good Recovery, 30% as Moderate Disability and 7% as Severe Disability. On the neurophysical and neuropsychological examinations, 77·2% had a good neurophysical outcome (namely, No Impairment or Mild Impairment), and a similar proportion was found for neuropsychological outcome, with 70·0% classified as No/Mild Impairment. For psychosocial outcome, by contrast, less than one-third of participants had a Good level of reintegration ($N = 20$, 28·6%), and the remaining 50 people had a Restricted reintegration, with varying levels of disability and handicap, classified as Substantially Limited (48·6%) or Poor (22·9%).

Table 2 presents the mean scores and standard deviations for the 12 predictor variables for subjects classified in the Good and Restricted subgroups for overall psychosocial outcome, along with group comparisons. The numbers of

Table 2. *Means and standard deviations of the predictor variables, along with results of group comparisons, for subjects classified as having Good or Restricted overall psychosocial outcome*

	Good ($N = 20$)		Restricted ($N = 50$)			
	Mean/N	S.D./%	Mean/N	S.D./%	t/χ^2	P
Age at injury	21·50	4·85	24·14	7·88	−1·70	NS
Gender						
Males	14	70·0	38	76·0		
Females	6	30·0	12	24·0	0·27	NS
Years schooling	9·40	1·27	9·40	1·20	0	NS
Occupational status	5·43	1·00	5·82	0·98	−1·52	NS
Pre-morbid problems						
Yes	1	5·0	10	20·0	2·43	NS
No	19	−95·0	40	80·0		
Days unresponsive	3·85	4·83	16·86	20·91	−4·10	< 0·001
Days PTA	32·30	18·38	78·44	53·96	−5·32	< 0·001
Months post-trauma	80·95	13·75	70·56	20·20	2·48	< 0·02
Self-esteem	65·00	20·68	56·48	23·04	1·44	NS
Disability rating	2·35	1·31	2·74	1·37	−1·09	NS
Neurophysical impairment						
None	10	50·0	14	28·0		
Mild	10	50·0	20	40·0		
Moderate	0	0	8	16·0	8·75	< 0·04
Severe	0	0	8	16·0		
Neuropsychological impairment						
None	13	65·0	15	30·0		
Mild	6	30·0	15	30·0		
Moderate	0	0	16	32·0	10·96	< 0·02
Severe	1	5·0	4	8·0		
Impairment in neurophysical domains						
Gait						
Yes	3	15·0	16	32·0	2·09	NS
No	17	85·0	34	68·0		
Spasticity						
Yes	0	0	6	12·5	2·74	NS
No	20	100	42	87·5		
Weakness						
Yes	0	0	4	8·5	1·81	NS
No	20	100	43	91·5		
Incoordination						
Yes	0	0	5	10·4	2·25	NS
No	20	100	43	89·6		
Impairment in neuropsychological domains						
Memory						
Yes	4	20·0	25	50·0	5·30	< 0·03
No	16	80·0	25	50·0		
Cognitive speed						
Yes	2	10·0	17	34·0	4·16	< 0·05
No	18	90·0	33	66·0		
Concept formation						
Yes	2	10·0	11	22·0	1·36	NS
No	18	90·0	39	78·0		
Behaviour regulation						
Yes	1	5·0	21	42·0	9·07	< 0·003
No	19	95·0	29	58·0		

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participants in the Good and Restricted categories for each of the three psychosocial domains (occupational activities, interpersonal relationships, and independent living skills) was different to that for the overall outcome. For occupational activities, Good and Restricted categories comprised 25 *versus* 45 participants respectively; interpersonal relationships comprised 26 *versus* 44 respectively; independent living skills consisted of 43 *versus* 27 respectively. Nonetheless, the descriptive data and group comparisons for the 12 predictor variables in each domain were very similar to those for overall outcome.

There were no biographical differences between participants with Good or Restricted reintegration. Of interest, no group differences were demonstrated for the participants' ratings of their self-esteem, or for their perception of the degree of disability they experienced. By contrast, the Restricted group had significantly more severe degrees of injury, as indicated by durations of unresponsiveness and PTA, and more severe neurophysical and neuropsychological impairments. Examining specific impairment domains, also reported in Table 2, there were no differences with respect to the proportion of participants experiencing significant problems (i.e. No/Mild impairment *versus* Moderate/Severe impairment) in any of the four neurophysical domains (gait, spasticity, weakness or incoordination) or impairments in concept formation. Significant group differences were found for neuropsychological impairments in memory, cognitive speed and behavioural regulation of abilities.

Initial screening of the predictor variables revealed substantial intercorrelations among two of the injury variables (unresponsiveness and PTA) and the impairment measures. PTA also showed the highest correlations with the outcome variables. Because the aim of the study was to further an understanding of the effects of specific impairments on psychosocial functioning, the above injury variables were excluded from further analysis in order to avoid problems with multi-collinearity. In so doing, however, it is understood that variables relating to severity of injury are probably most strongly related to outcome. A number of other statistically significant intercorrelations were present, but with one exception these were not high, ranging from 0·25 to 0·39. The correlation between occupational status and years of schooling was statistically significant ($r = 0{\cdot}51$, $P < 0{\cdot}001$) and because the latter variable had a lower correlation with psychosocial outcome than the occupational status variable, it was excluded from further analysis.

Table 3. *Predictors of overall psychosocial functioning*

	β	Wald	P	Odds
Age injury	0·08	1·42	NS	1·08
Gender	3·36	3·66	NS	28·72
Occupational status	−0·48	0·84	NS	0·62
Pre-morbid antisocial	−2·73	3·08	NS	0·07
Self-esteem	−0·10	6·20	0·013	0·91
Rating of disability	−0·33	0·88	NS	0·72
Time post-trauma	−0·09	7·21	0·008	0·91
Neurophysical impairment	2·58	7·24	0·008	13·17
Neuropsychological impairment	2·52	7·76	0·006	12·39

A direct logistic regression analysis was conducted with the remaining nine predictor variables and a dichotomized measure (overall psychosocial outcome) as the outcome variable. A test of the full model with all predictors against a constant-only model was statistically reliable ($\chi^2 = 43{\cdot}64$, $\mathrm{df} = 9$, $P = 0{\cdot}000$) indicating that these predictors, as a set, reliably distinguished between people with Good *versus* a Restricted psychosocial outcome. Prediction success was sound, with 75% of the individuals with Good outcome correctly classified (sensitivity), as were 92% of those with Restricted outcome (specificity), yielding an overall prediction of 87·14%. Positive predictive power (i.e. the proportion of individuals predicted to have a Good outcome being correctly classified) was 78·9%, and negative predictive power (i.e. the number of individuals predicted to have a Restricted outcome being correctly classified) was 90·2%. Table 3 shows the regression coefficient (β), Wald statistic, significance level and odds ratio for each of the nine predictors. According to the Wald criterion, only time post-trauma, self-esteem, neurophysical and neuropsychological impairments reliably predicted the model.

Given that impairments were a significant predictor of psychosocial outcome, the next question was whether some types of impairments were more important than others. Accordingly, a second regression analysis was run, using data from the four neuropsychological domains as

Table 4. *Correlation matrix among impairment variables*

	Neuropsychological domains				Neurophysical domains			
	1	2	3	4	5	6	7	8
1 Memory	—							
2 Cognitive speed	0·14	—						
3 Concept formation	0·19	0·12	—					
4 Behavioural regulation	0·35**	0·14	0·30*	—				
5 Gait	0·26*	0·13	0·04	0·21	—			
6 Spasticity	0·27*	0·04	0·14	0·23*	0·47***	—		
7 Weakness	0·29*	0·25*	0·05	0·24*	0·29*	0·50***	—	
8 Incoordination	0·23	0·31**	0·02	0·29*	0·34**	0·45***	0·54***	—
Neurophysical	0·32*	0·14	0·09	0·29	0·61***	0·61***	0·49***	0·56***
Neuropsychological	0·56***	0·46***	0·43**	0·54***	0·23	0·18	0·26	0·30

* $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$.

Table 5. *Predictors of specific aspects of psychosocial functioning: occupational activities, interpersonal relationships and independent living skills*

	Overall psychosocial outcome	Occupational activities	Interpersonal relationships	Independent living skills
χ^2 (df = 7)	31·13, $P = 0·000$	28·84, $P = 0·0002$	35·32, $P = 0·000$	39·47, $P = 0·000$
Specificity (%)	80·0	64·0	76·9	86·1
Sensitivity (%)	90·0	86·7	90·9	74·1
Positive predictive (%)	76·2	72·7	83·3	84·1
Negative predictive (%)	91·8	81·3	87·0	76·9
Significant predictor variables, with Wald (z) statistic	Behavioural regulation 4·50, $P = 0·034$ Time post-trauma 4·20, $P = 0·040$	Neurophysical impairment 4·87, $P = 0·003$ Memory 4·45, $P = 0·035$	Time post-trauma 6·88, $P = 0·009$ Cognitive speed 6·08, $P = 0·014$ Behavioural regulation 5·23, $P = 0·022$	Neurophysical impairment 9·23, $P = 0·002$ Behavioural regulation 4·68, $P = 0·031$ Memory 4·24, $P = 0·040$

the predictors, along with those variables significantly contributing to the model in the first analysis: time post-trauma, self-esteem and neurophysical impairment. The four variables comprising the Neurophysical Impairment Scale were not analysed separately because of the substantial intercorrelations among all variables (see Table 4). Moreover, there were no differences between psychosocial outcome groups on any of the four neurophysical domains when examined separately (see Table 2). Although two of the six intercorrelations among the neuropsychological variables were significant, their associations were only modest. The result of the logistic regression analysis was significant, as shown in Table 5, with sensitivity, specificity, positive and negative predictive power being comparable to the first analysis. The Wald criterion indicated that the only neuropsychological variable significantly contributing to the model was regulation of behaviour.

Similar analyses were conducted examining the three components of psychosocial reintegration, using the four neuropsychological domains, time post-trauma, self-esteem and neurophysical impairment as predictors. As shown in Table 5, in each case the chi-square statistic was significant, but different groups of variables were significant predictors of different aspects of psychosocial functioning: neurophysical impairment and memory predicted successful occupational activities; time post-trauma, cognitive speed and behavioural regulation for interpersonal relationships; and neurophysical impairment, behavioural regulation and memory for independent living skills.

DISCUSSION

In this group of very severely brain-injured adults, the initial severity of the injury, along with consequent neurophysical and neuro-

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psychological impairments, were the overriding determinants of psychosocial functioning. But they were not the only factors. Chronicity or time post-trauma and a non-neurological variable, level of self-esteem, also emerged as significant predictors of successful psychosocial reintegration in overall terms. These findings lend support to the importance of some of the non-neurological domains identified by Lishman (1973) and Kendall & Terry (1996) as being influential in psychosocial adjustment, although it is recognized that the correlational nature of the statistical analyses do not permit causal statements. Few studies have examined the predictive value of emotional factors on psychosocial outcome, yet this is clearly an area warranting further attention given our results, as well as Bowman's (1996) findings that emotional variables significantly predicted social activity, but not return to work (RTW). Investigation of other specific psychological variables is warranted, such as depression, which has been identified consistently in this clinical group.

In the light of these findings, it was of interest that the participants' ratings of their own handicap/disability did not emerge as a significant predictor. Other investigators, such as Moore *et al.* (1991), have found that locus of control beliefs were significantly related to outcome, and consequently they emphasized the importance of the subject's belief system (cf. cognitive appraisals). Inspection of Table 2, however, demonstrates that there were no significant differences between groups with Good *versus* Restricted psychosocial outcome with respect to the participant's ratings of their degree of handicap/disability. Moreover, a notable observation was that a large proportion of participants rated their degree of disability/handicap in the non-predicted direction: 27% of those with Moderate or Severe Disability rated themselves as having 'no' disability/handicap, whereas 14% of individuals with Good Recovery described themselves as having 'a lot' of handicap/disability.

This counter-intuitive variability in appraisals among individuals who, in objective terms, differ markedly in the degree of disability they experience, is reminiscent of van Zomeren & van den Burg's (1985) subgroups who complained 'too much' or 'too little'. They noted that it is difficult to determine whether those who complain 'too much' were 'anxious complainers' or 'keen observers'. Either way, these individuals would appear to be good candidates for psychotherapy aimed at dealing with issues pertaining to the consequences of the injury. By contrast, individuals who complain 'too little' are traditionally regarded as having poor insight into and awareness of their impairments and disabilities, which adversely impacts upon progress in therapy and psychosocial adjustment (e.g. Schacter *et al.* 1990; Ezrachi *et al.* 1991; Prigatano, 1991). A note of caution, however, is suggested by the findings of Moore *et al.* (1989): participants who made little use of active coping strategies showed less psychological distress than those using a wide range of coping strategies, the latter usually being seen as preferable. The authors concluded that 'perhaps some ''unrealistic'' feelings of control and well being should be encouraged rather than exposed for the ''falsehoods'' that they are.' (p. 175).

Rather surprisingly, chronicity was identified as a significant predictor of psychosocial adjustment, although this has been previously reported by other investigators (Klonoff *et al.* 1986; Heinemann & Whiteneck, 1995). Thus, it would appear that the passage of time, even in the outcome stage as late as the present study, continues to exert an effect on level of psychosocial functioning in individuals with severe degrees of TBI. These findings are contrary to the established view that 'outcome' is determined within the first year or two post-trauma. The empirical evidence for this position derives from studies using the Glasgow Outcome Scale. Jennett *et al.* (1981) reported that 90% of subjects classified as Good Recovery or Moderate Disability at 1 year were already in that outcome category at 6 months post-trauma. Hence, their conclusions related to whether the patient showed further recovery after 6 months that was of sufficient magnitude to warrant reclassification to a better outcome category. In the early months post-trauma, recovery is conceptualized within an organic context, neurogenic factors being responsible for return of function. Although central nervous system recovery may continue in the longer term, other psychosocial mechanisms should also be considered. An implication of these results is that psychosocial adjustment after severe degrees of TBI is a dynamic process, the time-frame being

a protracted one. This being the case, continued therapies including counselling, aimed at improving psychosocial adjustment are indicated for this clinical group. Confirmation of these findings, however, requires a longitudinal design.

Results of many previous studies reinforce the long-held belief that 'mental sequelae' contribute more to the final outcome than physical deficits. Certainly, there is empirical support for this view from the perspective of relatives of individuals with TBI, who rate cognitive and behavioural changes in the person with TBI as more stressful than physical changes (McKinlay *et al.* 1981; Brooks *et al.* 1986). Those data, however, do not address the psychosocial adjustment and outcomes of the TBI persons themselves. Moreover, there is evidence from studies that include neurophysical measures in their analyses that these types of impairments play an important a role in psychosocial adjustment. In Bond's (1975, 1976) pioneering study, correlations between social outcome on the one hand and mental and physical disability on the other were comparable ($r_s = 0{\cdot}54$ and 0·48 respectively), both significant at $P < 0{\cdot}001$. Examination of specific components of his scales revealed that a high degree of physical handicap was associated with loss of work capacity, but not leisure interests or family cohesion. By contrast, a high degree of cognitive handicap was associated with difficulties in a broader range of social factors. In the present study, degree of neurophysical impairment was a significant predictor, not only of psychosocial adjustment in overall terms, but also the specific domains of occupational activities and independent living skills. This pattern of findings is consistent with Bond's results. They also accord with clinical experience: those individuals who are left with moderate or severe neurophysical disability after TBI and their relatives can certainly vouch for the impact that this type of disability exerts upon their capacity for resuming pre-morbid roles, as well as their self-appraisals.

Neuropsychological impairments emerged as significant predictors of each of the psychosocial domains (occupational activities, interpersonal relationships and independent living skills), but more importantly specific types of impairment impacted differentially in psychosocial domains. It was expected that both memory and cognitive speed were significant factors, given that these deficits are characteristic of the TBI group. So too are impairments in executive function, but it was the behavioural–regulation component rather than the cognitive (concept formation) aspect which was more significant. To date, the so-called qualitative variables comprising behavioural regulation (e.g. rule breaking and perseveration) have not featured as prominently in the TBI research literature in comparison with cognitive variables. The present results demonstrate that these neuropsychological impairments, consistent with frontal systems dysfunction, are predictive of psychosocial adjustment in the domains of interpersonal relationships and independent living skills. In a similar vein, Ezrachi and colleagues (1991) found regulation of affect was a significant predictor of employment capacity. These authors also discuss the importance of including 'process measures' of ongoing behaviour and not relying exclusively upon measures 'easily obtained by history, testing or questionnaire' (Ezrachi *et al.* 1991, p. 72).

The present study provides a partial test of the model proposed by Kendall & Terry (1996), and a larger sample size would permit the inclusion of additional non-neurological measures. Other potentially important variables identified by Kendall & Terry include environmental resources such as social support and financial status, as well as mediating variables such as the individual's coping strategies. The present study focused upon objective levels of psychosocial adjustment, as rated by clinicians. Given the poor correspondence between the participant's appraisals of their level of disability and our measures of psychosocial adjustment, further exploration of psychosocial adjustment from the brain injured person's point of view, is warranted. Clearly, both perspectives are important.

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REFERENCES

Adams, J. H., Doyle, D., Graham, D. I., Lawrence, A. E., McLellan, D. R., Gennarelli, T. A., Pastusko, M. & Sakamoto, T. (1985). The contusion index: a reappraisal in human and experimental

non-missile head injury. *Neuropathology and Applied Neurobiology* **11**, 299–308.
Blumer, D. & Benson, D. F. (1975). Personality changes with frontal and temporal lobe lesions. In *Psychiatric Aspects of Neurologic Disease* (ed. D. F. Benson and D. Blumer), pp. 151–170. Grune & Stratton: New York.
Bond, M. R. (1975). Assessment of the psychosocial outcome after severe head injury. In *Outcome of Severe Damage to the Central Nervous System* Ciba Foundation Symposium 34 (new series). pp. 141–155. Elsevier: Amsterdam.
Bond, M. R. (1976). Assessment of the psychosocial outcome of severe head injury. *Acta Neurochirurgica* **34**, 57–70.
Bowman, M. L. (1996). Ecological validity of neuropsychological and other predictors following head injury. *Clinical Neuropsychologist* **10**, 382–396.
Brooks, N. (1989). Defining outcome. *Brain Injury* **3**, 325–329.
Brooks, N., Campsie, L., Symington, C., Beattie, A. & McKinlay, W. (1986). The five year outcome of severe blunt head injury: a relative's view. *Journal of Neurology, Neurosurgery, and Psychiatry* **49**, 764–770.
Burgess, P. W. & Shallice, T. (1996). Response suppression, initiation and strategy use following frontal lobe lesions. *Neuropsychologia* **34**, 263–273.
Buschke, H. & Fuld, P. A. (1974). Evaluating storage, retention, and retrieval in disordered memory learning. *Neurology* **24**, 1019–1025.
Coopersmith, S. (1981). *SEI. Self-Esteem Inventories*. Consulting Psychologists Press: Palo Alto, CA.
Crowe, S. F. (1992). Dissociation of two frontal syndromes by a test of verbal fluency. *Journal of Clinical and Experimental Neuropsychology* **14**, 327–339.
Daniel, A. (1983). *Power, Privilege and Prestige. Occupations in Australia*.Longman Cheshire: Melbourne.
DeFilippis, N. A. & McCampbell, E. (1979). *The Booklet Category Test*. Psychological Assessment Resources: Odessa, FL.
Ezrachi, O., Ben-Yishay, Y., Kay, T., Diller L. & Rattock, J. (1991). Predicting employment in traumatic brain injury following neuropsychological rehabilitation. *Journal of Head Trauma Rehabilitation* **6** (3), 71–84.
Godfrey, H. P. D., Knight, R. G. & Partridge, F. M. (1996). Emotional adjustment following traumatic brain injury: a stress-appraisal-coping formulation. *Journal of Head Trauma Rehabilitation* **11** (6), 29–40.
Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G. & Curtiss, G. (1993). *Wisconsin Card Sorting Test Manual. Revised and Expanded*. Psychological Assessment Resources: Odessa, FL.
Heinemann, A. W. & Whiteneck, G. G. (1995). Relationships among impairment, disability, handicap, and life satisfaction in persons with traumatic brain injury. *Journal of Head Trauma Rehabilitation* **10** (4), 54–63.
Ip, R. Y., Dornan, J. & Schentag, C. (1995). Traumatic brain injury: factors predicting return to work or school. *Brain Injury* **9**, 517–532.
Jennett, B. (1996). Epidemiology of head injury. *Journal of Neurology, Neurosurgery, and Psychiatry* **60**, 362–369.
Jennett, B. & Bond, M. R. (1975). Assessment of outcome after severe brain damage. A practical scale. *Lancet* i 480–484.
Jennett, B., Snoek, J., Bond, M. R. & Brooks, N. (1981). Disability after severe head injury: observations on the use of the Glasgow Outcome Scale. *Journal of Neurology, Neurosurgery, and Psychiatry* **44**, 285–293.
Johnstone, B. (1996). An editorial response to Smith-Knapp *et al*.'s 'Predicting independence from neuropsychological tests following traumatic brain injury'. *Brain Injury* **10**, 627–630.
Kendall, E. & Terry, D. J. (1996). Psychosocial adjustment following closed head injury. A model for understanding individual differences and predicting outcome. *Neuropsychological Rehabilitation* **6**, 101–132.
Klonoff, P. S., Costa, L. D. & Snow, W. G. (1986). Predictors and indicators of quality of life in patients with closed-head injury. *Journal of Clinical and Experimental Neuropsychology* **8**, 469–485.
Kraus, J. F., Black, M. A., Hessol, N., Ley, P., Rokaw, W., Sullivan, C., Bowers, S., Knowlton, S. & Marshall, L. (1984). The incidence of acute brain injury and serious impairment in a defined population. *American Journal of Epidemiology* **119**, 186–201.
Lazarus, R. S. & Folkman, S. (1984). *Stress Appraisal, and Coping*. Springer: New York.
Lishman, W. A. (1973). The psychiatric sequelae of head injury: a review. *Psychological Medicine* **3**, 304–318.
Luria, A. R. (1969). Frontal lobe syndromes. In *Handbook of Clinical Neurology, vol 2* (ed. P. J. Vinken and G. W. Bruyn), pp. 725–757. North Holland: Amsterdam.
Luria, A. R. (1973). *The Working Brain*. Penguin: London.
McKinlay, W. W., Brooks, D. N., Bond, M. R., Martinage, D. P. & Marshall, M. M. (1981). The short-term outcome of severe blunt head injury as reported by relatives of the injured person. *Journal of Neurology, Neurosurgery, and Psychiatry* **44**, 527–533.
McLean, A., Dikmen, S. S. & Temkin, N. R. (1993). Psychosocial recovery after head injury. *Archives of Physical Medicine and Rehabilitation* **74**, 1041–1046.
Masson, F., Maurette, P., Salmi, L. R., Dartigues, J.-F., Vecsey, J., Destaillats, J.-M. & Erny, P. (1996). Prevalence of impairments five years after a head injury, and their relationship with disabilities and outcome. *Brain Injury* **10**, 487–497.
Miller, L. (1985). Cognitive risk taking after frontal or temporal lobectomy – I. The synthesis of fragmented visual information. *Neuropsychologia* **23**, 359–369.
Miller, L. & Milner, B. (1985). Cognitive risk taking after frontal or temporal lobectomy – II. The synthesis of phonemic and semantic information. *Neuropsychologia* **23**, 371–379.
Milner, B. (1964). Some effects of frontal lobectomy in man. In *The Frontal Granular Cortex and Behavior* (ed. J. M. Warren and K. Akert), pp. 313–334. McGraw-Hill: New York.
Moore, A. D. & Stambrook, M. (1995). Cognitive moderators of outcome following traumatic brain injury: a conceptual model and implications for rehabilitation. *Brain Injury* **9**, 109–130.
Moore, A. D., Stambrook, M. & Peters, L. C. (1989). Coping strategies and adjustment after closed-head injury: a cluster analytical approach. *Brain Injury* **3**, 171–175.
Moore, A. D., Stambrook, M. & Wilson, K. G. (1991). Cognitive moderators in adjustment to chronic illness: locus of control beliefs following traumatic brain injury. *Neuropsychological Rehabilitation* **1**, 185–198.
Ponsford, J. L., Olver, J. H., Curran, C. & Ng, K. (1995). Prediction of employment status two years after traumatic brain injury. *Brain Injury* **9**, 11–20.
Prigatano, G. P. (1991). Disturbances of self-awareness of deficit after traumatic brain injury. In *Awareness of Deficit after Brain Injury. Clinical and Theoretical Issues* (ed. G. P. Prigatano and D. L. Schacter), pp. 111–126. Oxford University Press: New York.
Ruff, R. M., Marshall, L. F., Crouch, J., Klauber, M. R., Levin, H. S., Barth, J., Kreutzer, J., Blunt, B. A., Foulkes, M. A., Eisenberg, H. M., Jane, J. A. & Marmarou, A. (1993). Predictors of outcome following severe head trauma: follow-up data from the Traumatic Coma Data Bank. *Brain Injury* **7**, 101–111.
Schacter, D. L., Glisky, E. L. & McGlynn, S. M. (1990). Impact of memory disorder on everyday life: awareness of deficits and return to work. In *The Neuropsychology of Everyday Life: Assessment and Basic Competencies* (ed. D. E. Tupper and K. D. Cicerone), pp. 231–257. Kluwer Academic Publishers: Massachusetts.
Shallice, T. (1982). Specific impairments in planning. *Philosophical Transactions of the Royal Society of London* **298**, 199–209.
Smith-Knapp, K., Corrigan, J. D. & Arnett, J. A. (1996). Predicting functional independence from neuropsychological tests following traumatic brain injury. *Brain Injury* **10**, 651–661.
Tate, R. L., Broe, G. A. & Lulham, J. M. (1989*a*). Impairment after severe blunt head injury: the results from a consecutive series of 100 patients. *Acta Neurologica Scandinavica* **79**, 97–107.
Tate, R. L., Lulham, J. M., Broe, G. A., Strettles, B. & Pfaff, A. (1989*b*). Psychosocial outcome for the survivors of severe blunt head injury: The results from a consecutive series of 100 patients. *Journal of Neurology, Neurosurgery, and Psychiatry* **52**, 1128–1134.

Tate, R. L. (1999). Executive dysfunction and characterological changes after traumatic brain injury; two sides of the same coin. *Cortex* (in the press).

Tate, R. L., Hudgkinson, A. E., Veerabangsa, A. & Maggiotto, S. (1996). Measuring psychosocial outcome after traumatic brain injury: reliability and validity of a new scale. In *International Perspectives in Traumatic Brain Injury*, *Proceedings of the 5th Conference of the International Association for the Study of Traumatic Brain Injury and 20th Conference of the Australian Society for the Study of Brain Impairment* (ed. J. Ponsford, P. Snow and V. Anderson), pp. 415–419. The Australian Society for the Study of Brain Impairment: Melbourne.

Tate, R. L., McDonald, S. & Lulham, J. M. (1998). Incidence of hospital-treated traumatic brain injury in an Australian community. *Australian and New Zealand Journal of Public Health* **22**, 419–423.

Thomsen, I. V. (1984). Late outcome of very severe blunt head trauma: a 10–15 year second follow-up. *Journal of Neurology, Neurosurgery, and Psychiatry* **47**, 260–268.

van Zomeren, A. H. & van den Burg, W. (1985). Residual complaints of patients two years after severe head injury. *Journal of Neurology, Neurosurgery, and Psychiatry* **48**, 21–28.

Vilkki, J., Ahola, K., Holst, P., Ohman, J., Servo, A. & Heiskanen, O. (1994). Prediction of psychosocial recovery after head injury with cognitive tests and neurobehavioral ratings. *Journal of Clinical and Experimental Neuropsychology* **16**, 325–338.

Vogenthaler, D. R., Smith, K. R. & Goldfader, P. (1989). Head injury, a multivariate study: predicting long-term productivity and independent living outcome. *Brain Injury* **3**, 369–385.

Walsh, K. W. (1991). *Understanding Brain Damage. A Primer of Neuropsychological Evaluation. (2nd edn)*. Churchill Livingstone: Edinburgh.