A model of personality change after traumatic brain injury and the development of the Brain Injury Personality Scales

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Objective: The aims of this study were to develop models of personality change after traumatic brain injury (TBI) based on information provided by the TBI survivor and a significant other (SO), and to compare the models generated from the two different sources of information.

Methods: Individuals with and without TBI and an SO were interviewed separately about their current personality. The SOs were also interviewed about the personality of the TBI survivor before the injury. A subset of TBI survivors and their SOs were interviewed twice to assess test–retest reliability. Items which were not associated with personality change after TBI, which could not be measured reliably or which did not contribute to the model, were excluded.

Results: Of the 123 original items, 29 items from the interview with the survivor and 31 items from the interview with the SO were retained to form the Brain Injury Personality Scales. Separate factor analyses of ratings from each interview (survivor and SO) resulted in seven first order factors. The second order factor analyses for each interview resulted in four factors. Concordance between the information obtained from the two interviews was low.

Conclusions: The information obtained from the interviews with the TBI survivors and the SOs produced two models with a similar structure: three superordinate factors of personality items (affective regulation, behavioural regulation and engagement) and one superordinate factor of items relevant to mental state (restlessness and range of thought). Despite the similarity in structure, the content of the information obtained from the two interviews was different.

Gainotti¹ attributed the lack of progress in understanding the nature of personality change after traumatic brain injury (TBI) to the complexity of the problem and the dearth of instruments to investigate the change. In this report, we provide a theoretical framework to encourage future thinking on the matter. Our approach will address three issues that may have hindered progress in developing such a framework: (i) the population on which the model is developed, (ii) the source of information for generating the model and (iii) the procedure used for generating the model.

Population on which the model is developed

The models of personality underlying some of the scales currently in use to measure personality in TBI, for example the Neuropsychiatric Rating Scale (NRS)² and the Neuropsychology Behaviour and Affect Profile,³ were initially developed from populations other than TBI but later standardised on a group with TBI. These scales have been very useful but the use of scales developed for either the psychiatric population or for the general population, such as the NEO Personality Inventory (NEO-PI),⁴ can result in the imposition of a framework relevant to the personality of these populations onto the personality changes associated with TBI. In contrast with these scales, the NRS,⁵ the Current Personality Profile⁶ and the Head Injury Behaviour Scale⁷ were developed on the basis of information from individuals with TBI. Despite its usefulness, the Current Personality Profile has not led to a new theoretical framework. The Head Injury Behaviour Scale is a recent development, and it is premature to evaluate its contribution to our understanding of the organisation of personality after TBI. The NRS⁵ is a useful and popular measure of general neurobehavioural functioning. The factor structure

of the NRS provides a framework for general neurobehavioural changes but not specifically for personality.

Source of information for generating the model

It has been claimed that individuals with TBI have limited awareness of their cognitive and behavioural problems.^{8,9} A significant other (SO) is often recruited to provide information about the TBI survivor,⁶ and the discrepancy between the self-ratings by the TBI survivor and the ratings by the SO are thought to reflect the survivor's lack of insight.⁹ There is no evidence that the information from the TBI survivor is less accurate than the information from the SO. There is some evidence that lack of insight from the TBI survivor does not fully account for the discrepancy between the two sources of information, and that factors associated with the SO may also contribute to the discrepancy.¹⁰ The issue regarding the best source of information to generate a model of personality after TBI is still unresolved.

Procedure for generating the model

Investigators using a non-psychometric approach to personality after TBI grouped items intuitively to reduce the complexity of information.^{1,11,12} Investigators using the psychometric approach^{2,3,7} generated their models by carrying out factor analysis of items preselected for inclusion on the basis of clinical judgment, or because these items were part of a rating scale designed for another population. In each case, the factor analyses followed the selection of items.

Abbreviations: KMO, Kaiser–Meyer–Olkin; NEO-PI, NEO Personality Inventory; NRS, Neuropsychiatric Rating Scale; SO, significant other; TBI, traumatic brain injury

Table 1 Characteristics of the participants with and without brain injury

Characteristic	With TBI	Without TBI
Age at interview (y) (mean (SD) [range])	35.2 (10.1) [18.5–64.8]	35.8 (12.2) [18.8–67.6]
Age at injury (y) (mean (SD) [range])	28.8 (9.9) [16.0–59.0]	– –
Time since injury (y) (mean (SD) [range])	6.6 (6.3) [0.7–39.6]	– –
Sex (n)		
Male	152	57
Female	32	30
Level of education: percentage of sample (No of participants)		
No qualifications	10.9 (20)	3.4 (3)
Vocational training	7.6 (14)	6.9 (6)
Basic high school (standard grades/GCSE)	27.7 (51)	16.1 (14)
Vocational training + basic high school	10.3 (19)	6.9 (6)
Advanced high school (A levels/highers)	7.6 (14)	11.5 (10)
College education	17.9 (33)	17.2 (15)
University education	16.3 (30)	33.3 (29)
Postgraduate education	1.6 (3)	4.6 (4)
Type of occupation: percentage of sample (No of participants)		
Managers and senior officials	11.4 (21)	4.6 (4)
Professional occupations	15.8 (30)	28.7 (25)
Associate professional and technical occupations	13.6 (25)	25.3 (22)
Administrative and secretarial occupations	7.1 (13)	12.6 (11)
Skilled trade occupations	23.9 (44)	3.4 (3)
Personal service occupations	4.3 (8)	12.6 (11)
Sales and customer service occupations	3.3 (6)	1.1 (1)
Process, plant and machine operatives	9.8 (18)	0.0 (0)
Elementary occupations	7.6 (14)	5.7 (5)
Unemployed	2.7 (5)	5.7 (5)
Current occupational status: percentage of sample (No of participants)		
In rehabilitation	39.1 (72)	0 (0)
Unsupported employment	24.5 (45)	71.3 (62)
Unsupported education	8.2 (15)	17.2 (15)
Unemployed	28.3 (52)	11.5 (10)
Rehabilitation status: percentage of sample (No of participants)		
Never	15.8 (29)	100.0 (87)
Currently	39.1 (72)	0 (0)
Past	45.1 (83)	0 (0)

TBI, traumatic brain injury.

The current study

We describe our results leading to the development of a theoretical framework that reduces the complexity of the problem described by Gainotti.¹ Our approach was exploratory but was guided by clinical and statistical criteria similar to those used by Corrigan¹³: (i) the initial number of items for

rating should be over inclusive, (ii) the items entered into the factor analysis must be selected on the basis of well defined criteria (relevance to TBI, ease of interpretation, test–retest reliability), (iii) the final instrument should only include the items that contribute to the solution of the factor analysis and to the personality framework, (iv) the ratings of personality change should be completed by experienced interviewers on the basis of information provided directly and indirectly by the TBI survivor and an SO and (v) the information obtained from the TBI survivor might produce a different model of personality change than will the information provided by the SO, and the information from the two sources should initially be treated separately.

Table 2 Sex and relationship to participant of their significant other

Significant other	Percentage (n) of individuals	
	With TBI	Without TBI
Relationship to participant		
Partner/spouse	30.4 (56)	35.6 (31)
Mother	41.8 (77)	11.5 (10)
Father	8.7 (16)	3.4 (3)
Brother	2.7 (5)	3.4 (3)
Sister	8.2 (15)	1.1 (1)
Grandparent	0.5 (1)	0.0 (0)
Aunt or uncle	0.5 (1)	0.0 (0)
Other relative	1.1 (2)	5.7 (5)
Friend	6.0 (11)	39.1 (34)
Sex of significant other		
Female	79.9 (147)	66.7 (58)
Male	20.1 (37)	33.3 (29)

TBI, traumatic brain injury.

Table 3 Percentage of participants with traumatic brain injury from different sources

Source of participants	Percentage (n) of participants
Vocational rehabilitation	81.5 (150)
Community integration rehabilitation	3.3 (6)
Government social work services	5.4 (10)
Other vocational service	3.3 (6)
Other community service	4.9 (9)
Individuals waiting for rehabilitation	1.6 (3)

Table 4 Characteristics of injury and medication in the sample of participants with traumatic brain injury

Characteristic	Level	Percentage (n) of participants
Severity of injury	Moderate	17.9 (33)
	Severe	82.1 (151)
Medication	None	52.7 (97)
	Currently medicated	47.3 (87)

Our intention was to produce an initial model that was unambiguous rather than comprehensive, and that reflected the changes in personality most frequently observed. We excluded ambiguous items, items that were not associated with other items or items endorsed infrequently, however clinically salient, because they could decrease the clarity of the final model. To ensure the reliability of the resulting instrument, we excluded items that could not be reliably assessed.

METHODS

Participants

Participants were recruited from six urban centres in the UK (table 1). Only participants for whom an SO could provide information about their current personality, and in the case of TBI survivors their personality before the injury, were included in the study. The sex and relationship of the SO to the participant for both groups is provided in table 2. All participants and their SO gave written informed consent.

TBI survivors (n = 184) were recruited from private rehabilitation services and local social services (table 3). Participants were included in the study only if there was documented

evidence of a moderate to severe TBI (Glasgow Coma Scale of 12 or below, or a post-traumatic amnesia of more than 1 h) or if their records contained sufficient information to derive such a score (table 4). Individuals with injuries sustained by a penetrative missile were excluded from the study. The last TBI (some individuals had sustained more than one TBI) had occurred at least 3 months prior to the interview, and participants had to be 16 years of age or over at the time of the first or only TBI. Participants who had never had a TBI (n = 87) were recruited from a variety of sources (eg, large companies, friends of individuals with TBI).

Materials

A total of 123 personality characteristics were gathered from (1) the scientific and clinical literature on TBI, (2) existing personality assessment scales, (3) staff at the participating rehabilitation services, (4) clients of the participating rehabilitation services, (5) the Scale for the Assessment of Negative Symptoms¹⁴ and the Scale for the Assessment of Positive Symptoms,¹⁵ and (6) the scientific literature on personality disorder.

The participant was rated on each item on the basis of information obtained during a semi-structured interview. Some items were rated by observing the participant but most items were rated on the basis of information provided by the interviewee (participant or SO), either directly in response to questions or indirectly through conversation and observation. For example, to rate an item such as "quick temper", the interviewer not only considered the participant's view of their temper but also considered whether the participant lost his temper or seemed to become angry during the interview, or if the participant provided anecdotal evidence indicating a difficulty with temper.

Table 5 Rotated component matrix (Varimax rotation) of items from the interview with the traumatic brain injury survivor

Item	Component						
	1	2	3	4	5	6	7
Blaming others	0.713	0.314	0.040	0.086	-0.037	0.111	0.068
Resentfulness	0.780	0.013	0.094	-0.005	0.159	0.151	0.264
Passive aggression	0.719	0.172	0.063	0.099	0.145	0.215	-0.164
Quick temper	0.456	0.098	0.061	0.688	0.023	-0.149	0.087
Argumentative	0.654	0.136	0.161	0.333	-0.079	0.001	-0.007
Aggressive behaviour	0.476	0.360	-0.042	0.537	0.118	-0.023	0.233
Awkwardness	0.649	0.198	0.235	0.032	0.170	0.171	-0.172
Out of touch	0.138	0.615	-0.031	0.107	0.310	0.383	-0.077
Irresponsibility	0.226	0.708	0.03	-0.060	0.091	0.024	0.103
Dependence	-0.090	0.601	-0.035	0.214	0.340	0.228	0.025
Self-centredness	0.253	0.607	0.306	0.233	-0.035	0.040	-0.054
Insensitivity	0.395	0.611	-0.034	0.074	-0.075	0.148	0.009
Irrationality	0.358	0.494	0.134	0.107	-0.048	0.359	0.164
Loneliness	0.180	0.074	0.698	0.131	-0.031	0.168	0.228
Dissatisfaction/unhappiness	0.212	0.160	0.762	0.011	0.251	-0.132	0.030
Depressiveness	0.066	-0.056	0.799	0.313	0.060	-0.026	0.153
Self-esteem	0.065	-0.025	0.539	0.087	0.292	0.033	0.592
Changeability	-0.013	0.0004	0.487	0.588	-0.017	0.215	-0.074
Catastrophic reactions	-0.042	-0.008	0.233	0.619	0.173	0.112	0.186
Emotional disinhibition/lack of control	0.158	0.238	0.138	0.736	0.019	0.018	0.119
Recreational interests and activities	-0.025	0.229	0.086	0.098	0.556	0.064	0.344
Lifelessness/listlessness	0.120	0.135	0.353	0.089	0.705	-0.233	0.048
Intimacy and closeness	0.388	0.125	0.108	-0.205	0.535	0.001	0.112
Flattened affect	0.006	-0.078	-0.034	0.137	0.800	0.347	-0.036
Poverty of content of speech	0.117	0.144	-0.059	-0.017	0.133	0.804	-0.040
Preoccupations	0.246	0.225	0.114	0.003	0.056	0.777	0.074
Social disinhibition	0.425	0.274	0.055	0.204	-0.154	0.470	0.103
Confidence	-0.026	0.081	0.391	0.120	0.194	0.064	0.685
Anxiety	0.071	0.032	0.010	0.476	-0.055	-0.034	0.629
Percentage of variance	13.39	9.98	9.80	9.58	8.02	7.75	5.99

Factor loadings in **bold typeface** represent a significant loading (>0.450).

Table 6 Rotated component matrix (Varimax rotation) of items from the interview with the significant other

Item	Component						
	1	2	3	4	5	6	7
Criticism of others	0.543	0.315	-0.006	0.340	0.114	0.017	-0.066
Unreasonableness	0.594	0.420	-0.006	0.088	-0.024	0.146	0.164
Irritability	0.638	0.285	0.093	0.056	0.166	-0.015	0.314
Quick temper	0.806	0.053	0.147	0.086	0.101	0.033	0.118
Argumentative	0.670	0.154	0.038	0.193	0.173	0.157	-0.101
Aggressive behaviour	0.674	0.157	0.238	0.201	0.068	0.207	0.180
Impatience	0.495	0.132	0.320	0.292	-0.081	0.129	0.313
Changeability	0.461	0.215	0.285	0.149	0.296	0.023	0.274
Insensitivity	0.470	0.637	-0.014	0.285	0.107	0.043	0.156
Blaming others	0.369	0.478	0.027	0.226	-0.040	0.242	0.181
Self-centredness	0.144	0.754	-0.166	0.097	0.094	0.068	0.116
Lack of empathy	0.219	0.716	0.121	0.116	0.113	0.187	0.011
Intimacy and closeness	0.121	0.667	0.345	0.003	0.0003	0.094	-0.120
Self-esteem	-0.045	0.089	0.496	0.197	0.463	0.211	0.057
Worry	0.176	-0.124	0.726	0.082	0.262	0.092	-0.004
Anxiety	0.024	0.060	0.703	-0.079	0.049	0.092	0.319
Catastrophic reactions	0.301	0.216	0.597	0.199	0.191	0.087	0.082
Emotional disinhibition/lack of control	0.381	0.103	0.492	0.296	0.316	0.009	0.144
Tactlessness	0.213	0.199	0.199	0.748	0.099	-0.001	0.066
Social disinhibition	0.359	-0.002	0.048	0.721	0.114	0.112	0.009
Rashness/impulsivity	0.192	0.219	0.004	0.634	0.074	0.042	0.246
Loneliness	-0.072	0.203	0.210	0.114	0.619	0.189	0.297
Dissatisfaction/unhappiness	0.247	0.017	0.070	-0.011	0.782	0.094	-0.047
Depressiveness	0.205	0.030	0.278	0.148	0.754	-0.018	0.125
Recreational interests and activities	0.051	0.106	0.092	-0.049	0.249	0.678	0.062
Physical anergia	0.150	0.117	0.095	0.0005	0.150	0.743	0.087
Dependence	0.244	0.179	-0.006	0.111	-0.138	0.691	0.059
Initiative	-0.183	-0.004	0.324	0.425	-0.018	0.585	0.108
Boredom	0.183	0.060	-0.030	0.079	0.280	0.337	0.653
Restlessness	0.235	-0.060	0.269	0.058	0.019	-0.056	0.732
Social inattentiveness	0.066	0.236	0.197	0.330	0.081	0.219	0.557
Percentage of variance	13.90	9.57	8.72	8.02	7.80	7.55	6.60

Factor loadings in **bold typeface** represent a significant loading (>0.450).

The questions were designed to engage the interviewee in a conversation and allow the interviewer to rate the participant on each item. Questions were appropriately rephrased for the interview with the SO. The interview was always carried out in a particular order but the interviewers did not restrict themselves to the questions in the manual. They were encouraged to learn as much as possible about the participant in regard to the items using the questions as a starting point for conversation. The six interviewers were trained to carry out the interviews with a training video, practice sessions and meetings between interviewers to discuss any difficulties in interviewing and methods to overcome the difficulties.

The interviewers were provided with a clear definition of each item, illustrative examples and instructions for rating. Each item was rated on a scale from 0 to 5 (not applicable, questionable, mild, moderate, marked and severe), as for the Scale for the Assessment of Negative Symptoms¹⁴ and the

Scale for the Assessment of Positive Symptoms.¹⁵ The manual for the interview can be obtained from the first author (MCO).

Procedure

All TBI survivors and their SO were interviewed at least once. Each SO was interviewed about the participant's current personality (during the past 3 months) and the participant's personality prior to the injury. Thirty of the TBI survivors were interviewed twice (at a 2 week interval), as was their SOs, to assess the test-retest reliability. These four interviews (two interviews with the TBI survivor and two interviews with the SO) were recorded on an audio tape, and the recorded interviews were rated by a second rater to assess inter-rater reliability. The same second rater scored all four interviews (two with the TBI survivor, two with the SO) from one particular participant.

Table 7 Characteristics of the solutions to the factor analyses

Criterion	First order factor analyses		Second order factor analyses		
	Survivor	SO	Survivor	SO	Combined
Bartlett's test of sphericity	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
KMO	0.820	0.868	0.777	0.806	0.820
Range of individual KMOs	0.653–0.890	0.708–0.924	0.723–0.831	0.760–0.910	0.744–0.927
Range of communalities	0.502–0.787	0.510–0.745	0.754–0.985	0.652–0.972	0.600–0.794
% Residuals	33	32	23	38	46
Total variance explained (%)	64.50	62.15	86.09	84.66	70.26

KMO, Kaiser-Meyer-Olkin; SO, significant other.

Table 8 Rotated component matrix (Varimax rotation) from the second order factor analysis from the interview with the traumatic brain injury survivor (four factor solution)

Factor from table 5	Component			
	1	2	3	4
7	0.902	0.0518	0.110	0.138
3	0.838	0.101	0.213	0.179
4	0.573	0.141	0.714	−0.00425
5	0.102	0.934	0.134	0.05537
2	0.06133	0.727	0.414	0.225
1	0.140	0.369	0.845	0.144
6	0.229	0.163	0.09798	0.947
% Variance explained	27.57	22.78	21.13	14.60

Factor loadings in **bold typeface** represent a significant loading (>0.450).

Data analysis

Item selection was carried out in seven steps. We excluded items (i) that had not been scored on a sufficient number of people, (ii) where only 10% of survivors obtained a score of 3 or more (moderate to severe), (iii) for which there was no difference between the ratings of individuals with TBI and individuals without injury, (iv) for which there was no difference between the ratings before and after the injury, (v) that had a test–retest reliability of less than 0.6, (vi) that correlated with two or fewer items only and (vi) that had a Kaiser–Meyer–Olkin (KMO) value of less than 0.5. The test–retest reliability of each item was assessed by calculating the within subject generalisability coefficients.¹⁶ The ratings of the first interview (the ratings of the interviewer and the ratings of the rater of the audio tapes) were compared with the ratings of the second interview (the ratings of the interview and the ratings of the rater of the audio tape). The within subjects (test–retest) and between subjects (inter-rater reliability) coefficients of the factors will be detailed in a subsequent report describing the psychometric properties of the Brain Injury Personality Scales.

Factor analysis

The items selected from the two interviews were entered into separate principal component analysis with Varimax rotation. Items had to load on a factor at 0.450 to be considered significant. This criterion loading has been suggested for a sample of 150–200 participants.¹⁷

The principal criterion for factor extraction was an eigenvalue of 1.0 or greater. At one point in the process, extraction according to this criterion resulted in eight factors, with one factor having no significant loadings. The scree plots indicated the presence of seven factors, and the analysis was repeated with a specification to extract seven factors.

Three indices of extraction adequacy were examined for every factor solution generated: the KMO statistic (a measure of sampling adequacy, with a criterion of greater than 0.5), the communality (criterion of greater than 0.5) and the definition of the factors (criterion of at least three items loading significantly on a factor). Each of these criteria was considered in this order. If the extraction solution resulted in the violation of one of these criteria, the item that most violated the criterion was removed from the analysis, and another extraction procedure was carried out. The final solution satisfied all three criteria of sampling adequacy, communality and factor definition.

For the final solutions, Bartlett's statistic had to indicate a significant difference between the correlation matrix generated by the items and an identity matrix. Fewer than 50% of the residuals were allowed to not fit the model. Simple

Table 9 Rotated component matrix (Varimax rotation) from the second order factor analysis from the interview with the significant other (four factor solution)

Factor from table 6	Component			
	1	2	3	4
2	0.857	0.09861	−0.015	0.271
1	0.834	0.268	0.232	0.101
4	0.711	0.212	0.319	−0.00301
5	0.160	0.900	0.113	0.134
3	0.257	0.840	0.215	0.132
7	0.245	0.238	0.895	0.185
6	0.189	0.193	0.165	0.934
% Variance explained	30.31	24.79	14.91	14.64

Factor loadings in **bold typeface** represent a significant loading (>0.450).

structure was a desirable but not a necessary outcome as the items represent psychological constructs that may not be unitary.

After the separate factor analyses of the information obtained from the two interviews, we carried out a joint second order factor analysis of all first order factors obtained from the two interviews.

RESULTS

Of the 123 original items, 29 satisfied all of the criteria for the interview with the TBI survivor and 31 items for the interview with the SO. Eighteen items were selected from both interviews. Scores for some of these items were unavailable from some participants, and the remaining statistical procedures were carried out on 152 TBI survivors and 174 SOs.

The optimal solution for both factor analyses was seven factors (tables 5, 6). The solutions presented with complex structure; some items (quick temper, aggressive behaviour, self-esteem, changeability) loaded significantly on two factors. All indices confirmed the adequacy of the solutions for both interviews (table 7).

Unit weighed scores for each of the seven factors were calculated and subjected to a second order factor analysis (principal components analyses with Varimax rotation). The initial two factor solution showed low communalities (0.324) and a high percentage of residuals, indicating that the solution was not optimal for these items. A three factor solution resulted in little change. A four factor solution (tables 8, 9) led to substantial improvement (table 7).

The relationship between the personality items, the first order factors and the second order factors for the two interviews are shown in figs 1 and 2. The items are shown in the bottom layer, the first order factors in the middle layer and the second order factors in the top layer. Solid lines show the relationship between the different layers. For example, in fig 1, the first order factor "emotional lability" loads on two second order factors: "behavioural regulation" and "affective regulation".

The distribution of participants with and without TBI across the different scoring categories for each personality dimension is shown in fig 3. Participants with no TBI obtained higher ratings in the none or questionable categories, and participants with TBI obtained higher ratings in the mild, moderate and marked categories. Very few TBI survivors from this sample obtained ratings in the severe category. The ratings obtained from the interview with the TBI survivor indicated that depressiveness, lack of confidence and emotional lability were the most salient characteristics (fig 3C), and the ratings from the interview with the SO reflected the salience of depressiveness, anxiety, restlessness and disinhibition (fig 3D).

Figure 1 Relationships between items, first order factors and second order factors from information from the interview with the traumatic brain injury survivors. The personality items form the lower layer of the figure, the first order factors form the middle layer and the second order factors form the top layer.

To compare the results from the two interviews, we first compared the number of participants who showed little or pronounced personality change according to the information from the two interviews (table 10). We defined a pronounced personality change as a score of moderate, marked or severe on at least one dimension. The κ coefficient ($\kappa = 0.276$, $p = 0.010$) indicated poor agreement between the two interviews. We then carried out a combined factor analysis of the data from both interviews. There were 147 TBI survivors for whom the information from the two interviews was complete. The seven first order factors from the two interviews were combined into one factor analysis using the same procedure and criteria as for the previous analyses. The result was also a four factor solution (table 11). Six of the seven first order factors from the interview with the SO loaded on one factor (factor 1). The first order factors from the interview with the survivor were distributed more evenly across factors 2, 3 and 4. Indices of the adequacy of the solution are given in table 7.

DISCUSSION

The aim of this study was to develop a model of the components of personality that change after TBI and to develop a method of measuring this personality in a way consistent with the model. The main difference between this and previous approaches is that we used strict statistical criteria to select items for the factor analysis,¹³ and we further excluded items that interfered with an optimal factor solution, rather than using factor analysis to examine the factor structure of preselected items.^{2, 3, 7}

Our approach resulted in a list of descriptors that differentiated individuals with TBI from those without brain injury, and distinguished between the personality of the TBI survivor before and after the injury. First and second order factor analyses of these descriptors yielded clear factor solutions but some of these first order factors were highly intercorrelated. Second order factor analyses revealed these relationships more clearly. Hierarchical models^{18, 19} provide the opportunity to test the reliability and discriminant validity of psychological constructs at different levels. Discriminant validity can be low for single descriptors but is usually higher for first and second order factors.¹⁹ The validity of the components of the current model still needs to be examined.

The selection of items on a statistical basis results in a clear model of personality structure but the model may achieve clarity at the expense of completeness. Some items that reflect clinically salient aspects of personality associated with TBI (eg, tactlessness, childishness) were excluded from the model by the statistical process. Future research will examine the relationship between these items and this initial model.

We made no assumption about the degree of similarity between the information provided from the interviews with the TBI survivor and the SO. Item selection and factor analysis of the items from the two sources were carried out separately. There was considerable similarity, and some important differences, between the models produced from the two sources of information. Item selection from each interview yielded about 30 items, and 18 of these 30 items were shared between the two interviews. The second order factor analyses of both sets of descriptors yielded four factors. Approximately 70% of the total

Figure 2 Relationships between items, first order factors and second order factors from information from the interview with the significant other. The personality items form the lower layer of the figure, the first order factors form the middle layer and the second order factors form the top layer.

Figure 3 The percentage of participants who scored in different categories for each personality dimension. The legend on the left refers to (A) and (B), and the legend on the right refers to (C) and (D). Each colour represents one of the superordinate factors: behavioural regulation (red), affect regulation (blue), engagement (black) and mental states (green).

variance of both second order factor analyses was accounted for by three factors so similar in the composition of their items and in their first order factors that we named the three factors from each interview in the same way: behavioural regulation, affective regulation and engagement. The fourth factors from the two interviews (restlessness and range of thought) accounted for approximately 15% of the variance for each solution.

Between 64% and 82% of our sample, depending on the source of the information, showed a change in personality (a score of moderate or more) in at least one of these factors.

Table 10 Number and percentage of participants with brain injury who scored low (scores of none, questionable or mild) and high (moderate, marked or severe) on at least one dimension

Group	Score	Interview with the survivor			
		Low	High	Total	Percentage
Interview with the SO With TBI	Low	20	12	32	17.6
	High	45	105	150	82.4
	Total	65	117	182	100.0
	Percentage	35.7	64.3	100.0	
Without TBI	Low	63	8	71	81.6
	High	10	6	16	18.4
	Total	73	14	87	100.0
	Percentage	83.9	16.1	100.0	

Table 11 Rotated component matrix (Varimax rotation) from the second order factor analysis of items from both interviews

Factors from tables 5 and 6*	Component			
	1	2	3	4
<i>Restlessness</i>	0.742	0.211	0.079	0.109
<i>Hostility</i>	0.726	0.129	0.477	0.032
<i>Lack of empathy</i>	0.641	-0.132	0.386	0.227
<i>Anxiety</i>	0.633	0.044	0.444	0.016
<i>Disinhibition</i>	0.625	0.529	-0.030	0.307
<i>Social engagement</i>	0.508	0.526	-0.056	0.328
Depressiveness	0.025	0.852	0.188	0.110
Confidence	0.056	0.847	0.034	0.181
Emotional lability	0.312	0.695	0.423	-0.114
Oppositionality	0.171	0.344	0.799	-0.090
Social engagement	0.189	0.073	0.765	0.295
Emotional engagement	0.207	0.044	0.688	0.297
Depressiveness	0.355	0.048	0.113	0.747
Range of thought	-0.027	0.329	0.309	0.704
Percentage of variance explained	20.53	20.00	18.60	11.13

*The factors listed in italic were the factors from the interview with the significant other, and the factors in normal font were from the interview with the traumatic brain injury survivor. Factor loadings in **bold typeface** represent a significant loading (>0.450).

These values are similar to those reported by other investigators²⁰ but it is difficult to compare this incidence of personality change to the incidence reported by other investigators because of differences between studies, including differences in the method and nature of assessment, and the range of severity of injury. For example, the incidence of personality change has been reported to be as low as 3.5% in individuals with mild TBI²¹ and 84% in individuals with severe TBI.²²

The three shared second order factors appeared to bear some similarity to factors and dimensions suggested by other investigators who examined personality change after TBI. The affective and behavioural regulation factors are conceptually similar to the emotional and behavioural regulation factors,⁷ to the affective instability and aggression/disinhibition factors² and to the dimensions of emotional and social disturbances¹ described by previous investigators. The engagement factor is conceptually similar to the negative symptom factors^{5, 11} and the apathy factor.² These factors and dimensions from various investigators may share some conceptual features but their psychometric similarities still need to be tested. Nevertheless, the resemblances between the three major second factors from both interviews and factors generated by other investigators indicate that these dimensions are salient aspects of personality change after TBI, and provide some face validity for these three factors.

The fourth factors from each interview account for a smaller proportion of the total variance and resemble psychological states that are usually assessed with a psychiatric mental state examination.²³ Restlessness is a well documented outcome of TBI^{11, 24} and the items in the factor reflect attention that is broad and easily distracted. The range of thought factor is a possible name for a group of items that appear to reflect a narrow range in the content of thought. TBI survivors scoring high on this factor report that they have a limited number of concerns (preoccupations, as reflected by thinking or speaking about a narrow range of issues and interests). This restricted range of concerns is possibly reflected in their conversations (poverty of content of speech, as shown by over abstract, over concrete, repetitive or stereotyped speech) and in other aspects of social interaction (social disinhibition, as shown by an unawareness of the normal social rules of interaction). The restlessness and range of thought factors were generated as part of the reliable factor solutions but they consist of few items, account for little variance and are not constructs usually associated with personality. Additional research will examine their relationship to this model of personality change and their relevance to other samples of TBI survivors.

Despite the similarity in the structure of the models generated from the two interviews, there are important differences in their composition, as demonstrated by the lack of agreement between the factors from the two interviews. Discrepancy between ratings of personality by survivors of TBI and SOs has been frequently observed.^{9, 25, 26} Personality ratings of healthy individuals obtained by self and others also show some discrepancy. Correlations between self and peer ratings of personality are in the range of 0.25 and 0.36,²⁷ and self-spouse agreement on the NEO-PI ranges from 0.36 to 0.58.²⁸ The lack of concordance between the two interviews in this report, despite the apparent similarity in the structure of the models generated by these interviews, could arise because the two sources of information are providing different but equally valid information about the TBI survivor and because the validity of the information from one or both sources is compromised in some way. Our results provide some preliminary evidence for this second possibility. The fact that the factors generated from the interview with the SO correlated more highly with one another than with similar factors from the interview with the

TBI survivor may indicate that an additional variable (eg, SO burden) is exerting an influence on the information provided by the SO. It is premature to claim that one source of information is more reliable than the other, and it may prove more useful to examine more closely the nature of the information obtained from the survivor and the SO.

The current study has a number of limitations. First, our sample may not be representative of the population with TBI, despite our efforts to recruit participants from six major centres in the UK (three cities in England and three centres in Scotland). Item selection may have proceeded differently with a different sample. The influence of this possible problem on the development of the model is attenuated by the use of second order factors that depend less on the presence or absence of individual items and more on clusters of items. Second, the Brain Injury Personality Scales was the only measure of personality used in this study, and consequently there is no external or independent criterion against which to compare or validate the Brain Injury Personality Scales. The absence of such a gold standard in this study reflects the lack of consensus on models of personality change after TBI. There is an urgent need to compare the current models and the current measurements empirically. Until this is done, there is no way of knowing if the current models are sympathetic to one another, or if they are measuring different aspects of personality. It is also not possible to speculate on the sensitivity, validity or accuracy of the current measurement instruments. Third, there was no objective indication of the current functioning of the participating TBI survivors. Nevertheless, we did have some indication of their poor social functioning by the fact that they were either attending rehabilitation services or were in contact with social services. Fourth, the demographic differences between the TBI and non-TBI groups may have affected the selection of items. The true influence of the demographic differences on item selection may be difficult to assess but only a small proportion of the total number of items were excluded on the basis of a significant difference in score between the participants with and without TBI. Fifth, the development of the model depends largely on information obtained from the SO, including information about the personality of the TBI survivor before the injury. There is evidence that information provided by an SO about the current personality is subject to bias²⁹ but the extent of bias in the information about the personality before the injury, especially when the injury occurred over 20 years previous to the interview, is not known.

The model we describe provides a framework to organise the components of personality that are changed after brain injury. The model was developed with well defined clinical and statistical criteria, and its structure was generated with information from the TBI survivor or from the SO. However, it has not been subjected to confirmatory factor analysis, does not include some clinically salient aspects of personality and the information obtained from the TBI survivor did not agree with the information provided by the SO. The model requires additional development but we hope that this framework can serve as a guide to future thinking about personality change after TBI.

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REFERENCES

- 1 **Gainotti G**. Emotional and psychosocial problems after brain injury. *Neuropsychol Rehabil* 1993;**3**:259–77.
- 2 **Max JE**, Castillo CS, Lindgren SD, *et al*. The Neuropsychiatric Rating Schedule: reliability and validity. *J Am Acad Child Adolesc Psychiatry* 1998;**37**:297–304.
- 3 **Nelson LD**, Satz P, Mitrushina M, *et al*. Development and validation of the Neuropsychology Behavior and Affect Profile. *Psychol Assess* 1989;**1**:266–72.
- 4 **Lannoo E**, de Deyne C, Colardyn F, *et al*. Personality change following head injury: Assessment with the NEO Five-Factor Inventory. *J Psychosom Res* 1997;**43**:505–11.
- 5 **Levin HS**, High WM, Goethe KE, *et al*. The Neurobehavioral Rating Scale: assessment of the behavioral sequelae of head injury by the clinician. *J Neurol Neurosurg Psychiatry* 1987;**50**:183–93.
- 6 **Brooks DN**, McKinlay WW. Personality and behavioural change after severe blunt head injury—a relative's view. *J Neurol Neurosurg Psychiatry* 1983;**46**:336–44.
- 7 **Godfrey HPD**, Harnett MA, Knight RG, *et al*. Assessing distress in caregivers of people with a traumatic brain injury (TBI): a psychometric study of the Head Injury Behaviour Scale. *Brain Inj* 2003;**17**:427–35.
- 8 **Sherer M**, Boake C, Levein E, *et al*. Characteristics of impaired awareness after traumatic brain injury. *J Int Neuropsychol Soc* 1998;**4**:380–7.
- 9 **Bogod NM**, Mateer CA, MacDonald SWS. Self-awareness after traumatic brain injury: a comparison of measures and their relationship to executive functions. *J Int Neuropsychol Soc* 2003;**9**:450–8.
- 10 **Lanham RA Jr**, Weissenburger JE, Schwab KA, *et al*. A longitudinal investigation of the concordance between individuals with traumatic brain injury and family or friend ratings on the Katz Adjustment Scale. *J Head Trauma Rehabil* 2000;**15**:1123–38.
- 11 **Eames P**, Wood R. Rehabilitation after severe brain injury: a special-unit approach to behaviour disorders. *Int Rehabil Med* 1985;**7**:130–3.
- 12 **Blumer D**, Benson DF. Personality changes with frontal and temporal lobe lesions. In: Benson DF, Blumer D, eds. *Psychiatric aspects of neurological disease*. New York: Grune & Stratton, 1975:151–88.
- 13 **Corrigan JD**. Development of a scale for assessment of agitation following traumatic brain injury. *J Clin Exp Neuropsychol* 1989;**11**:261–77.
- 14 **Andreasen NC**. *The Scale for the Assessment of Negative Symptoms (SANS)*. Iowa City: University of Iowa, 1983.
- 15 **Andreasen NC**. *The Scale for the Assessment of Positive Symptoms (SAPS)*. Iowa City: University of Iowa, 1984.
- 16 **Cronbach LJ**, Gleser GC, Nanda H, *et al*. *The dependability of behavioral measurements: theory of generalizability for scores and profiles*. New York: John Wiley and Sons, 1972.
- 17 **Hair JF**, Anderson RE, Tatham RL, *et al*. *Multivariate data analysis*. New Jersey: Prentice Hall, 1998.
- 18 **Eysenck HJ**, Eysenck MW. *Personality and individual differences*. New York: Plenum Press, 1985.
- 19 **Watson D**. *Mood and temperament*. New York: The Guildford Press, 2000:31–61.
- 20 **Prigatano GP**. Personality disturbances associated with traumatic brain injury. *J Consult Clin Psychol* 1992;**60**:360–8.
- 21 **Adler A**. Mental symptoms following head injury: a statistical analysis of two hundred cases. *Arch Neurol Psychiatry* 1945;**53**:34–43.
- 22 **Thomsen IV**. The patient with severe head injury and his family: a follow-up study of 50 patients. *Scand J Rehabil Med* 1974;**6**:180–3.
- 23 **Pridmore S**. *The psychiatric interview: a guide to history taking and the mental state examination*. Amsterdam: Harwood Academic Publishers, 2000.
- 24 **Sachdev P**, Kruk J. Restlessness: the anatomy of a neuropsychiatric symptom. *Aust N Z J Psychiatry* 1996;**30**:38–53.
- 25 **Cavallo MM**, Kay T, Ezrachi O. Problems and changes after traumatic brain injury: differing perceptions within and between families. *Brain Inj* 1992;**6**:327–35.
- 26 **Fordyce DJ**, Roueche JR. Changes in perspectives of disability among patients, staff and relatives during rehabilitation of brain injury. *Rehabil Psychol* 1986;**31**:217–29.
- 27 **Watson D**, Clark LA. Self- versus peer-ratings of specific emotional traits: evidence for convergent and discriminant validity. *J Pers Soc Psychol* 1991;**60**:927–40.
- 28 **McCrae RR**. Consensual validation of personality traits: evidence from self-reports and ratings. *J Pers Soc Psychol* 1982;**43**:293–303.
- 29 **McKinlay WW**, Brooks DN. Methodological problems in assessing psychosocial recovery following severe head injury. *J Clin Neuropsychol* 1984;**6**:87–99.

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