

APPENDIX 1 – Online supplemental digital content

Assessment of the measurement quality of an instrument within the Rasch analysis framework (Pellicciari et al. 2018)

Measurement quality domain/parameter	Indicator	Expected values / findings
Internal Construct Validity (Rasch model's requirements)		
Item invariance or item homogeneity^A		
Visual assessment of individual ICC ^{A1}	Visual inspection	Observed probabilities (class intervals) should match expected probabilities
Assessment of item fit residuals ^{A2}	Individual item fit residual ^{A2.1}	Between -2.5 and +2.5
	Summary item fit residual (mean) ^{A2.2}	Around 0 in case of a perfect fit
	Summary item fit residual (standard deviation) ^{A2.2}	Around 1 in case of a perfect fit
Assessment of item-trait interaction ^{A3}	Chi-square for individual items ^{A3.1}	Non-significant (Bonferroni corrected)
	Summary chi-square across all items ^{A3.2}	Non-significant (Bonferroni corrected)
Item hierarchy: face validity ^{A4}	Visual inspection	Item hierarchy conforms to theoretical expectations
Person invariance^B		
Assessment of person fit residuals	Person fit residual ^{B1}	Between -2.5 and +2.5
	Summary person fit residual (mean) ^{B2}	Around 0 in case of a perfect fit
	Summary person fit residual (standard deviation) ^{B3}	Around 1 in case of a perfect fit
Unidimensionality^C	Paired t-test on PCA of residuals	PST<5% or a lower bound confidence interval (LBCI) PST<5%
Local independence^D	Correlation amongst items' residuals	<Local Dependency Relative Cut-off
Invariance for subgroups (no DIF)^E	Uniform DIF: Two way ANOVA	The main effect is non-significant (Bonferroni corrected)
	Non-Uniform DIF: Two way ANOVA	
Monotonicity^F	Visual inspection of each item's thresholds	All thresholds ordered
Reliability		
Classic reliability		
Distribution-dependent CCT separation ^{G1}	Cronbach's alpha	≥.70 for group measurement; ≥.90 for person measurement at the individual level
Measurement error ^{G2}	Standard Error of Measurement (SEM)	Expected to be as low as possible
Rasch reliability		
Distribution-dependent separation ^{H1}	Person Separation Index (PSI)	≥.70 for group measurement; ≥.90 for individual person measurement
Distribution-dependent strata ^{H2}	Number of strata (H)	≥2 strata for group measurement; ≥4 strata for person measurement
Distribution-independent strata ^{H3}	Number of DLPA	≥2 DLPA for group measurement; ≥4 DLPA for person measurement
Distribution-independent separation ^{H4}	Distribution independent PSI (DI-PSI)	≥.70 for group measurement; ≥.90 for person measurement at the individual level
Information ^{H5}	Item and Test information	Expected to follow a normal distribution (higher in the middle of the measurement range)
Targeting		
Targeting ^{I1}	Targeting Index	< 1 : good targeting; >[1 , 2]: fair targeting; > 2 : poor targeting (indicate absolute values)
Ceiling effect ^{I2}	Calculation of % of persons with maximum score	<2%: good; [2%, 5%]: fair; >5%: poor
Floor effect ^{I2}	Calculation of % of persons with minimum score	2%: good; [2%, 5%]: fair; >5%: poor

NOTES.

- ^A **Item invariance (or homogeneity)**. The items should maintain their stochastic ordering along with the whole latent trait (Andrich 1988; Tennant and Conaghan 2007). This essential Rasch model requirement is assessed in several ways:
 - ^{A1} **Fit to the model for items (I): visual assessment of the Item Characteristic Curve (ICC) for a given item**. The ICC is a visual indicator of the model's fit, which displays the expected probabilities to pass the item for any ability level along the measurement continuum. To assess fit to the model, another curve is constructed by connecting the observed probabilities values across groups representing different ability levels (called class intervals). The match between the two curves is then assessed (Hobart and Cano 2009). A good match between the two curves for any given class interval suggests an adequate fit to the model. However, there are several anomalies which could be appraised:
 - ^{A1.1} Item under-discrimination: a flatter observed probability curve indicates that the item is under-discriminating (please see also note ^{A2.1}), i.e., the responses to the item are too erratic, suggesting that the responses to the item are influenced by a different latent variable (Hobart and Cano 2009).
 - ^{A1.2} Item over-discrimination: on the other hand, a steeper curve suggests that the item is over-discriminating (please see also note ^{A2.1}), i.e., the responses to the item lacks the expected randomness and tend to be too deterministic (Hobart and Cano 2009).
 - ^{A1.3} Increased item-trait interaction: independently from item discrimination, the presence of one or more individual class interval markedly outside the expected probability curve for a given item suggest that responses to that item, at some ability levels, deviate from the model's expectations. This implies that the item does not maintain its stochastic ordering along with the measurement trait, thus violating the invariance (homogeneity) of the item hierarchy (please see also note ^{A3.1}) (Andrich 1988; Hobart and Cano 2009).
 - ^{A2} **Fit to the model for items (II): Item fit residuals (iFitRes)**. iFitRes are the standardized sum of all differences between the observed and expected values summed over all persons for items (Tennant and Conaghan 2007; Hobart and Cano 2009). These can be evaluated:
 - ^{A2.1}At the individual item level: iFitRes for a given item is expected to be 0 in case of achievement of a perfect probabilistic Guttman pattern. In case of an adequate fit to the model, they are expected to be in the range [-2.5, +2.5], which represents the 99% confidence interval around the iFitRes (Pallant and Tennant 2007; Hobart and Cano 2009). Values outside this confidence interval for a given item suggest misfit:
 - Values >+2.5: these are indicative of item under-discrimination (please see also note ^{A1.1}), which suggests that the observed response tends to follow less the expected Guttman pattern (i.e., excessively random).
 - Values <-2.5: these are indicative of item over-discrimination (please see also note ^{A1.2}), which suggests that the observed responses tend to be deterministic (i.e., lacking the expected randomness).
 - ^{A2.2}As a summary indicator: fit to the model for individual items can be summarized as a mean and a standard deviation of the iFitRes (please see note ^{A2.1}). In case of perfect fit to the model, such means and standard deviations are expected to assume values equal to zero and, respectively, one, as they are transformed to approximate a z score, representing a standardized normal distribution (Pallant and Tennant 2007).
 - ^{A3} **Fit to the model for items (III): Item-trait interaction**. This refers directly to the Rasch model's statistical property of homogeneity or item invariance³¹. Item-trait interaction can be evaluated:
 - ^{A3.1}At the item level: The χ^2 statistics summarizes whether item invariance is achieved by comparing the differences between the expected values and observed values across groups representing different ability levels (called class intervals) and across the trait to be measured (please see also note ^{A1.3}). When significant (taking into account a Bonferroni-corrected p-value) for an item, the latter violates the invariance of the item hierarchy, which suggests that this item does not fit the Rasch model (Hobart and Cano 2009).
 - ^{A3.2}As a summary indicator: This total χ^2 is calculated by summing up the chi-squares of the individual items (please see note ^{A3.1}) divided by the sum of their degrees of freedom minus one (Tennant and Conaghan 2007; Hobart and Cano 2009). As for the item-trait interaction χ^2 for individual items, when significant below the Bonferroni-

corrected p-value, this χ^2 suggests that the data do not fit the Rasch model as the item hierarchy as a whole do not maintain its stochastic ordering along the whole measurement continuum.

- **^{A4} Fit to the model for items (IV): face validity of the item difficulty order.** This is a conceptual indicator of fit. The item difficulty order suggested by the analysis should make sense from a clinical point of view and be consistent with the expectations derived from theory. If this is the case, it provides evidence towards the construct validity of the item set concerning the variable being measured (Hobart and Cano 2009). If this is not the case, the statistical fit to the Rasch model may have capitalized on chance.
- **^B Fit to the model for persons: Person fit residuals (pFitRes).** The pFitRes are the standardized sum of all differences between observed and expected values summed over all items for persons (Tennant and Conaghan 2007; Hobart and Cano 2009). As for items (please see note ^{A2}), these can be evaluated:
 - ^{B1}At the individual person level: pFitRes for a given person is expected to be 0 in case of achievement of a perfect probabilistic Guttman pattern. In case of an adequate fit to the model, they are expected to be in the range [-2.5, +2.5], which represents the 99% confidence interval around the pFitRes (Pallant and Tennant 2007; Hobart and Cano 2009). Values outside this confidence interval for a given person suggest misfit:
 - Values >+2.5: these are indicative of person under-discrimination (please see also note^{A2}), which suggests that the observed response tends to follow less the expected Guttman pattern (i.e., excessively random).
 - Values <-2.5: these are indicative of person over-discrimination (please see also note^{A2}), which suggests that the observed responses tend to be deterministic (i.e., lacking the expected randomness).
 - ^{B2}As a summary indicator: Fit to the model for individual persons can be summarized as a mean and a standard deviation of the pFitRes (please see note^{B1}). In case of perfect fit to the model, such means and standard deviations are expected to assume values equal to zero and, respectively, one, as they are transformed to approximate a z score, representing a standardized normal distribution (Pallant and Tennant 2007).
- **^C Unidimensionality requirement.** All items should measure a single underlying construct (Tennant and Conaghan 2007; Kreiner 2013). Unidimensionality is tested post-hoc with a paired t-test on separate estimates for each respondent (derived from subsets of items identified by the principal component analysis of the item residuals) (Smith 2002). Unidimensionality is considered achieved when the PST (percentage of significant t-test) is <5% (strict unidimensionality), or the LBCI (lower bound of the binomial confidence interval for proportions) is <5% (acceptable unidimensionality) (Tennant and Conaghan 2007).
- **^D Local Independence requirement.** All the variation among responses to an item should be accounted for by the person's ability and, therefore, for the same value of ability, there should be no further systematic relationship among responses (local independence requirement) (Kreiner 2013). Items are considered to be locally dependent if their residual correlation is above a Local Dependency Relative Cutoff (LDRC), calculated by adding .2 to the average of residual correlations, after having removed the correlation of each item to itself, equal to 1^(Marais 2013). Violations of local dependency may be indicative of (Marais and Andrich 2008b, 2008a):
 - Multidimensionality: although items are requested to be unidimensional, they should also measure different facets of the same construct. However, when some items differ between each other too much, multidimensionality arises as a violation of the local independence requirement. This violation is suggested by high residual correlations, a decreased person reliability, and a reduced variance of the person estimates (Marais and Andrich 2008b).
 - Response dependence: this occurs when a person's response to an item depends on the person's response to a previous item. In other words, the two dependent items, although unidimensional, measure a similar aspect of the same construct. This is suggested by a high residual correlation between the two dependent items, increased person reliability, and increased variance of the person estimates (Marais and Andrich 2008b).
- **^E Invariance for subgroup (absence of Differential Item Functioning – DIF - or item bias) requirement.** DIF occurs when an item, regardless of maintaining its stochastic ordering at the whole sample level (please see note ^{A3}), shows a lack of invariance, i.e., DIF, across relevant subgroups (or person factors), such as gender or age (Tennant and Conaghan 2007; Kreiner 2013). In this case, different groups of persons within a person factor respond differently based on their group membership, despite equal levels of the underlying characteristics. The presence of DIF is tested by a two-way ANOVA for each item, where scores are compared across each level of the person factor and different ability levels, as summarized by the class intervals (please see

note^{A1} for a definition of a class interval) (Pallant and Tennant 2007). DIF is present when the results of ANOVA are significant (p-values are Bonferroni-corrected). Two types of DIF can be observed:

- Uniform-DIF (U-DIF): the item bias is systematic along with the trait, as suggested by a significant main effect for the person factor (Pallant and Tennant 2007).
- Non-Uniform-DIF (NU-DIF): the item bias varies along with the trait, as suggested by a significant interaction effect (person factor × class interval) (Pallant and Tennant 2007).
- ^F **Monotonicity requirement.** The probability of endorsing an item response indicating higher ability should increase as the underlying level of the latent trait increases (monotonicity requirement) (Mesbah and Kreiner 2013). As a consequence, the difficulty thresholds (i.e., transition point between adjacent scoring categories) appear ordered. In the case of polytomous items, if the response options for a given item are used inconsistently (e.g., because of misinterpretation of the scoring options, caused by too many scoring options or by inaccurate labeling of the options), the difficulty thresholds appear disordered (Tennant and Conaghan 2007).
- ^{G1} Cronbach's α (Classical Test Theory reliability) is derived as the proportion of variance of the true score and the total variance, including error (Hobart and Cano 2009). It is an indicator of internal consistency because it is a function of the average inter-item correlations (Brodersen et al. 2013). This statistic is distribution-dependent (Wright 2001). $\geq .70$ and $\geq .90$ are considered the absolute minimum for the group and individual person measurements, respectively (Brodersen et al. 2013; Revicki et al. 2014).
- ^{G2} Closely related to the concept of reliability within the Classical Test Theory framework is that of the Standard Error of Measurement (SEM), that is calculated as follows: $SEM = SD \times \sqrt{1-r}$, where SD is the standard deviation of the person measures and r is the reliability coefficient (i.e., the Cronbach's alpha). It indicates the dispersion of the measurement errors when trying to estimate person abilities from their observed scores. It is less meaningful within the Rasch analysis framework, as in the latter, the standard errors are individually calculated for each person measurement (Hobart and Cano 2009). However, it is here reported as it is used to calculate the targeting index (please see note¹¹).
- ^{H1} PSI is calculated as the ratio between the variance among the estimates of persons tested and the error variance for each person; it indicates how reliably the persons are separated (Hobart and Cano 2009). Also, this statistic is distribution-dependent, meaning that if the data are skewed for the occurrence of the floor and/or ceiling effects, the PSI will be reduced (Wright 2001). On the other hand, when the distribution of the data is not skewed, the values of PSI and Cronbach's α are virtually identical (Marais 2013). $\geq .70$ and $\geq .90$ are considered the absolute minimum for the group and individual person measurements, respectively (Brodersen et al. 2013; Revicki et al. 2014), as explained in note^{G1}.
- ^{H2} Strata (H) are the number of statistically distinct levels of person ability (person strata) that the scale can reliably distinguish (Wright and Masters 1982; Fisher 1992). This statistics is based on the PSI and, therefore, it is distribution-dependent, as it assumes a normally-distributed sample (Wright 2001). If $PSI = .700$, then $H=2$ (minimum requirement for group measurement); if $PSI = .900$, then $H=4$ (minimum requirement for individual person measurement) (Fisher 1992).
- ^{H3} DLPA's are the number of statistically distinct levels of person ability that the scale can reliably distinguish independently from the distribution of the sample (Wright 2001). Unlike strata (please see note^{H3}), this statistic does not assume a normally-distributed example (Wright 2001).
- ^{H4} DI-PSI is the distribution-independent PSI, calculated using the formula $DLPA^2 / (1/DLPA^2)$ (Wright 2001). This indicator may be useful for skewed samples where the PSI values may grossly under-estimate the separation reliability of the scale (Wright 2001).
- ^{H5} Information (I) (Salzberger 2003; Kreiner and Christensen 2013) for a given item is calculated as follows: $I = \frac{1}{SE^2}$, i.e., the reciprocal of the squared standard error around the person measure. It is a measure of the precision of the estimation of a person's ability within the range of measurement of the item (Salzberger 2003). Over the items in a test, individual item information adds up to test information (Salzberger 2003).
- ¹¹ The targeting index is calculated as the ratio between the Person locations' mean and the SEM (Standard Error of Measurement; please see note^{G2} for the formula) (Fisher 2007). It indicates how the average person location has moved away from the average item difficulty, set by default at 0 logits.
- ¹² Ceiling and floor effects indicate how many persons in the sample have received the higher and, respectively, the lower scores of the scale (Fisher 2007).

References for Appendix 1

- Andrich D (1988) Rasch models for measurement. Sage Publications., London.
- Brodersen J, Doward LC, Thorsen H, Mckenna SP (2013) Writing health-related items for Rasch models - Patient-Reported Outcome Scales for Health Sciences: from medical paternalism to patient autonomy. In: Christensen KB, Kreiner S, Mesbah M (eds) in Rasch Models in Health. ISTE Ltd and John Wiley & Sons, Inc, London UK, Hoboken NJ.
- Fisher WJ (1992) Reliability, Separation, Strata Statistics. Rasch Measure Trans 1992:238.
- Fisher WPj (2007) Rating Scale Instrument Quality Criteria. Rasch Measurement Transactions 21:1:1095.
- Hobart J, Cano S (2009) Improving the evaluation of therapeutic interventions in multiple sclerosis: the role of new psychometric methods. In: Health Technology Assessment (accessed on 02/07/09 from <http://www.journalslibrary.nihr.ac.uk/hta/volume-13/issue-12#hometab0>), vol 13:12.
- Kreiner S (2013) The Rasch model for dichotomous items. In: Christensen KB, Kreiner S, Mesbah M (eds) in Rasch Models in Health. ISTE Ltd and John Wiley & Sons, Inc, London UK, Hoboken NJ.
- Kreiner S, Christensen KB (2013) Person parameter estimation and measurement in Rasch Models. In: Christensen KB, Kreiner S, Mesbah M (eds) in Rasch Models in Health. ISTE Ltd and John Wiley & Sons, Inc, London UK, Hoboken NJ.
- Marais I (2013) Local Dependence. In: Christensen KB, Kreiner S, Mesbah M (eds) in Rasch Models in Health. ISTE Ltd and John Wiley & Sons, Inc, London UK, Hoboken NJ.
- Marais I, Andrich D (2008a) Effects of varying magnitude and patterns of response dependence in the unidimensional Rasch model. J Appl Meas 9:105-124.
- Marais I, Andrich D (2008b) Formalizing dimension and response violations of local independence in the unidimensional Rasch model. J Appl Meas 9:200-215.
- Mesbah M, Kreiner S (2013) Rasch models for ordered polytomous categories. In: Christensen KB, Kreiner S, Mesbah M (eds) in Rasch Models in Health. ISTE Ltd and John Wiley & Sons, Inc, London UK, Hoboken NJ.
- Pallant JF, Tennant A (2007) An introduction to the Rasch measurement model: an example using the Hospital Anxiety and Depression Scale (HADS). Br J Clin Psychol 46:1-18.
- Pellicciari L, Piscitelli D, Caselli S, La Porta F (2018) A Rasch analysis of the Conley Scale in patients admitted to a general hospital. Disabil Rehabil:1-10 doi: 10.1080/09638288.2018.1478000.
- Revicki DA, Chen W, Tucker CA (2014) Developing item banks for patient-reported health outcomes. In: Reise PS, Revicki DA (eds) Handbook of Item Response Theory Modeling: applications to typical performance assessments, New York.
- Salzberger T (2003) Item Information: When Gaps Can Be Bridged. Rasch Measurement Transactions 17:1:910-911.
- Smith E (2002) Detecting and evaluating the impact of multidimensionality using item fit statistics and principal component analysis of residuals. Journal of Applied Measurement 3:205-231.
- Tennant A, Conaghan PG (2007) The Rasch measurement model in rheumatology: what is it and why use it? When should it be applied, and what should one look for in a Rasch paper? Arthritis Rheum 57:1358-1362 doi: 10.1002/art.23108.
- Wright BD (2001) Separation, Reliability and Skewed Distributions: Statistically Different Levels of Performance. Rasch Measure Trans 14(4).
- Wright BD, Masters GN (1982) Rating Scale Analysis. MESA Press, Chicago.

APPENDIX 2 – Online supplemental digital content

Table 2a. Item content, fit statistics, and scoring model for the final solution of the BIRT Motivation Questionnaire (N=308)

Retained items (increasing difficulty from top to bottom)	Conceptual facet	Item Parameters and Fit Statistics					Scoring Model
		Location	SE	FR	χ^2	Prob ^a	
BMQ14. I feel tired	Affective/emotional	-0.839	0.086	0.520	0.876	0.9279	0 1 2 3
BMQ16. It takes longer to finish things these days	Lack of organization	-0.797	0.076	1.838	7.097	0.1309	0 1 2 3
BMQ31. I get distracted from what I am doing	Distractability/Persever	-0.691	0.079	-0.513	2.576	0.6310	0 1 2 3
BMQ11. I have lots of 'get up and go'	Affective/emotional	-0.535	0.073	0.843	7.414	0.1156	0 1 2 3
BMQ22. I feel confident	Affective/emotional	-0.453	0.073	1.418	3.892	0.4208	0 1 2 3
BMQ08. I make the same mistakes over and over again	Distractability/Persever	-0.184	0.082	-0.158	3.876	0.4231	0 1 2 3
BMQ27. I have doubts about what I can achieve	Indecision/lack of ideas	-0.138	0.081	0.491	3.800	0.4338	0 1 2 3
BMQ12. I avoid doing things I do not have to	Difficulty to initiate	-0.118	0.077	0.897	2.896	0.5754	0 1 2 3
BMQ07. It is hard to decide what I want when people give me choices about things	Indecision/lack of ideas	0.054	0.084	0.111	2.302	0.6804	0 1 2 3
BMQ23. I think of things to do but never get around to doing them	Difficulty to initiate	0.096	0.081	0.418	4.990	0.2883	0 1 2 3
BMQ25. I feel I have got nothing done all day	Affective/emotional	0.115	0.079	1.616	10.592	0.0316	0 1 2 3
BMQ02. I leave things until the last minute	Difficulty to initiate	0.128	0.084	0.352	1.728	0.7857	0 1 2 3
BMQ20. It is hard to think of things to do	Indecision/lack of ideas	0.147	0.079	-1.340	5.577	0.2330	0 1 2 3
BMQ26. I am disorganised	Lack of organization	0.161	0.080	-1.917	14.371	0.0062	0 1 2 3
BMQ19. I finish things I start	Lack of organization	0.264	0.082	-0.915	1.921	0.7502	0 1 2 3
BMQ15. I get/do things in the wrong order	Lack of organization	0.645	0.092	-1.933	10.247	0.0365	0 1 2 3
BMQ28. I try hard	Affective/emotional	0.672	0.087	0.428	5.479	0.2416	0 1 2 3
BMQ03. I am late for appointments	Lack of organization	0.697	0.090	2.833	16.193	0.0028	0 1 2 3
BMQ04. I cannot be bothered to do important things, even though I know I should	Affective/emotional	0.774	0.090	0.751	5.375	0.2510	0 1 2 3
Deleted items (in order of deletion from top to bottom)	Conceptual facet	Reasons for deletion					Scoring Model
BMQ30. I feel energetic	Affective/emotional	Local dependency					0 1 2 3
BMQ05. I get muddled	Indecision/lack of ideas	Local dependency					0 1 2 3
BMQ09. I can concentrate for long periods	Distractability/Persever	Local dependency					0 1 2 3
BMQ13. I feel satisfied when I have finished something	Affective/emotional	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BMQ24. I am an enthusiastic person	Affective/emotional	Local dependency					0 1 2 3
BMQ06. I plan my week and make arrangements for things to do	Lack of organization	Misfitting (underfitting with significant chi-square)					0 1 2 3
BMQ32. I am good at making new friends	Affective/emotional	Misfitting (underfitting with significant chi-square)					0 1 2 3
BMQ18. I am interested in my appearance	Affective/emotional	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BMQ33. I know what I want	Indecision/lack of ideas	Local dependency and uniform DIF for time since lesion					0 1 2 3
BMQ29. I enjoy life	Affective/emotional	Uniform DIF for responder					0 1 2 3
BMQ21. I achieve my goals	Affective/emotional	Local dependency and rescored					0 1 1 2
BMQ34. I give my all	Affective/emotional	Local dependency					0 1 2 3
BMQ10. It is hard to get started, even when I know have got something to do	Difficulty to initiate	Local dependency and misfitting (significant chi-square)					0 1 2 3
BMQ17. I feel frustrated	Affective/emotional	Local dependency					0 1 2 3
BMQ01. I find it hard to get out of bed in the morning	Affective/emotional	Local dependency and rescored					0 1 1 2

Abbreviations: BMQ, BIRT Motivation Questionnaire; FR, fit residual; Prob, χ^2 probability; SE, standard error; χ^2 , chi-square; DIF, Differential Item Functioning.

Notes: The second column from the left contains the conceptual facets identified within the questionnaire: affective/emotional (including anhedonia, hopelessness, indifference, and lethargy), indecision/lack of ideas, difficulties to initiate a task, lack of organization, and distractability/perseverance. The location is expressed in logits. The degrees of freedom for each χ^2 were 4 for all items. The original scoring pattern for all items was 0 1 2 3. The lower part of the table displays the 15 items which were progressively deleted (from top to bottom) together with the reasons for their deletion.

^aBonferroni-corrected p-value was set at 0.0026, indicative of statistical significance at the 0.05 level.

Table 2b. Item content, fit statistics, and scoring model for the final solution of the BIRT Emotional Regulation Questionnaire (N=308)

Retained items (increasing difficulty from top to bottom)	Conceptual facet	Item Parameters and Fit Statistics					Scoring Model
		Location	SE	FR	χ^2	Prob ^a	
BREQ01. I have sudden mood swings	Lability/mood swings	-1.099	0.088	-2.126	10.716	0.0300	0 1 2 3
BREQ20. I am a calm person	Emotional control/Irritability	-0.812	0.087	1.461	4.542	0.3376	0 1 2 3
BREQ21. I sulk when I have been in a bad mood	Emotional control/Irritability	-0.650	0.087	1.707	12.913	0.0117	0 1 2 3
BREQ03. I am unpredictable	Lability/mood swings	-0.577	0.085	1.576	5.516	0.2384	0 1 2 3
BREQ30. I get upset	Emotional control/Irritability	-0.473	0.093	-1.166	3.344	0.5020	0 1 2 3
BREQ22. It is hard for people to get through to me when I am upset	Emotional control/Irritability	-0.346	0.110	0.758	1.778	0.7766	0 1 1 2
BREQ32. I snap at people	Emotional control/Irritability	-0.132	0.091	0.487	2.158	0.7068	0 1 2 3
BREQ27. When I get into a rage everything becomes a blur	Outburst consequences	-0.077	0.089	-1.713	3.390	0.4947	0 1 2 3
BREQ17. I feel anxious for no reason	No reason/cause	-0.033	0.092	-0.217	1.017	0.9072	0 1 2 3
BREQ15. I feel tired after I have been in a rage	Outburst consequences	-0.022	0.092	-0.718	12.091	0.0167	0 1 2 3
BREQ10. I get into a rage	Emotional control/Irritability	0.300	0.099	-0.134	1.925	0.7496	0 1 2 3
BREQ19. I do not understand why I am upset	No reason/cause	0.336	0.100	0.012	4.521	0.3401	0 1 2 3
BREQ07. I cannot remember what happens when I lose my temper	Outburst consequences	0.409	0.121	-1.238	8.402	0.0779	0 1 1 2
BREQ31. When I am angry, I do not understand why	No reason/cause	0.591	0.104	-1.138	3.962	0.4112	0 1 2 3
BREQ14. I cry for no reason	No reason/cause	0.633	0.107	1.947	4.932	0.2944	0 1 2 3
BREQ09. I feel upset for no reason	No reason/cause	0.667	0.103	-1.514	5.496	0.2400	0 1 2 3
BREQ23. I break things I value when I am in a temper	Emotional control/Irritability	1.286	0.161	-0.962	2.798	0.5921	0 1 1 2
Deleted items (in order of deletion from top to bottom)	Conceptual facet	Reasons for deletion					Scoring Model
BREQ05. My mood can change quickly for no reason	No reason/cause	Local dependency and misfitting (overfitting)					0 1 2 3
BREQ18. I am happy one moment and sad the next	Lability/mood swings	Local dependency					0 1 2 3
BREQ25. I don't understand the way I feel	No reason/cause	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BREQ16. I lose my temper	Emotional control/Irritability	Local dependency and misfitting (overfitting)					0 1 2 3
BREQ28. I lose my temper and then regret it	Outburst consequences	Local dependency, misfitting (underfitting with significant chi-square), and rescored					0 1 1 2
BREQ24. I am relaxed	Emotional control/Irritability	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BREQ08. I laugh for no reason	No reason/cause	Local dependency, misfitting (underfitting with significant chi-square), and rescored					0 1 1 2
BREQ12. I am in control	Emotional control/Irritability	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BREQ02. I lose my temper very suddenly without knowing why	No reason/cause	Local dependency and misfitting (overfitting)					0 1 2 3
BREQ11. I feel really sad and do not know why	No reason/cause	Local dependency and misfitting (significant chi-square)					0 1 2 3
BREQ06. I feel embarrassed when I lose my temper	Outburst consequences	Misfitting (underfitting with significant chi-square) and rescored					0 1 1 2
BREQ26. I suddenly feel angry and do not know why	No reason/cause	Local dependency					0 1 2 3
BREQ04. I find it hard to keep my temper under control	Emotional control/Irritability	Local dependency					0 1 2 3
BREQ29. When I get angry I take it out on the people closest to me	Emotional control/Irritability	Local dependency, uniform DIF for time since lesion, and rescored					0 1 1 2
BREQ13. I get a headache when I've been in a rage	Outburst consequences	Local dependency and rescored					0 1 1 2

Abbreviations: BREQ, BIRT Emotional Regulation Questionnaire; FR, fit residual; Prob, χ^2 probability; SE, standard error; χ^2 , chi-square; DIF, Differential Item Functioning.

Notes: The second column contains the conceptual facets identified within the questionnaire: emotional lability/mood swings, irritability/lack of emotional control/inappropriate behavior, no reasons/cause for the behavior, and outburst consequences. The location is expressed in logits. The degrees of freedom for each χ^2 were 4 for all items. The original scoring pattern for all items was 0 1 2 3. The lower part of the table displays the 15 items which were progressively deleted (from top to bottom) together with the reasons for their deletion.

^aBonferroni-corrected p-value was set at 0.0029, indicative of statistical significance at the 0.05 level.

Table 2c. Item content, fit statistics, and scoring model for the final solution of the BIRT Social Cognition Questionnaire (N=308)

Retained items (increasing difficulty from top to bottom)	Conceptual facet	Item Parameters and Fit Statistics					Scoring Model
		Location	SE	FR	χ^2	Prob ^a	
BSCQ09. I am amusing	Social anxiety	-1.050	0.081	-0.562	1.492	0.8280	0 1 2 3
BSCQ20. I feel comfortable in social situations	Social anxiety	-0.786	0.073	-0.336	7.194	0.1260	0 1 2 3
BSCQ11. I am relaxed around other people	Social anxiety	-0.686	0.075	0.439	1.927	0.7492	0 1 2 3
BSCQ16. I prefer being on my own than with others	Social interaction	-0.451	0.108	-0.859	7.526	0.1106	0 1 1 2
BSCQ06. I find it hard to imagine things in the future	Theory of mind/Empathy	-0.414	0.102	0.347	2.779	0.5955	0 1 1 2
BSCQ12. I find it hard to tell how people feel	Theory of mind/Empathy	-0.011	0.118	1.719	5.051	0.2821	0 1 1 2
BSCQ10. I find it hard to make friends	Social interaction	0.111	0.084	-1.551	7.703	0.1031	0 1 2 3
BSCQ28. I get confused when talking in a group of people	Social anxiety	0.175	0.109	-0.256	1.339	0.8548	0 1 1 2
BSCQ27. I enjoy other people's company	Social interaction	0.214	0.086	0.448	1.456	0.8344	0 1 2 3
BSCQ01. I feel left out of conversations	Social interaction	0.489	0.093	-0.976	3.790	0.4351	0 1 2 3
BSCQ03. People misunderstand me	Theory of mind/Empathy	0.549	0.122	0.880	0.413	0.9814	0 1 1 2
BSCQ04. I find it hard to understand people on the telephone	External cues	0.767	0.106	0.124	1.646	0.8004	0 1 2 3
BSCQ24. People get cross with me for no reason	Theory of mind/Empathy	1.092	0.119	0.341	4.761	0.3127	0 1 2 3
Deleted items (in order of deletion from top to bottom)	Conceptual facet	Reasons for deletion					Scoring model
BSCQ02. I find it hard to understand what people mean	External cues	Local dependency					0 1 2 3
BSCQ18. I misunderstand people	External cues	Local dependency					0 1 2 3
BSCQ14. I say things at the wrong time	External cues	Local dependency					0 1 2 3
BSCQ23. I enjoy socialising	Social interaction	Local dependency					0 1 2 3
BSCQ22. I am a loner	Social anxiety	Local dependency and rescored					0 1 1 2
BSCQ17. I feel isolated even when there are people around me	Social interaction	Local dependency, misfitting (significant chi-square), and rescored					0 1 1 2
BSCQ19. I worry about what other people think	-	Misfitting (undefitting with significant chi-square)					0 1 2 3
BSCQ08. I spend time with friends	Social interaction	Local dependency and uniform DIF for aetiology					0 1 2 3
BSCQ07. I do not understand why people behave the way they do	Theory of mind/Empathy	Local dependency and uniform DIF for education					0 1 2 3
BSCQ21. I feel left out at parties or social events	Social interaction	Local dependency and rescored					0 1 1 2
BSCQ13. I am a sociable person	Social anxiety	Local dependency					0 1 2 3
BSCQ15. It is hard to tell if people like me	Theory of mind/Empathy	Misfitting (significant chi-square) and rescored					0 1 1 2
BSCQ26. I am polite	Social anxiety	Misfitting (significant chi-square)					0 1 2 3
BSCQ25. I say the wrong thing	External cues	Local dependency and rescored					0 1 1 2
BSCQ05. I get instructions wrong	External cues	Local dependency					0 1 2 3

Abbreviations: BSCQ, BIRT Social Cognition Questionnaire; FR, fit residual; Prob, χ^2 probability; SE, standard error; χ^2 , chi-square; DIF, Differential Item Functioning.

Notes: The second column from the left contains the conceptual facets identified within the questionnaire: inability to interpret external cues, lack of empathy/theory of mind, social anxiety, and problems in social interaction. The location is expressed in logits. The degrees of freedom for each χ^2 were 4 for all items. The original scoring pattern for all items was 0 1 2 3. The lower part of the table displays the 15 items which were progressively deleted (from top to bottom) together with the reasons for their deletion.

^aBonferroni-corrected p-value was set at 0.0038, indicative of statistical significance at the 0.05 level.

Table 2d. Item content, fit statistics, and scoring model for the final solution of the BIRT Disinhibition Questionnaire (N=308)

Retained items (increasing difficulty from top to bottom)	Conceptual facet	Item Parameters and Fit Statistics					Scoring Model			
		Location	SE	FR	χ^2	Prob ^a				
BDQ16. It is hard not to say something once I have thought of it	Inhibition of verbal behavior/lack of tact	-0.838	0.076	0.132	1.459	0.8339	0	1	2	3
BDQ24. I can hold back my feelings	Inhibition of verbal behavior/lack of tact	-0.809	0.075	1.755	2.827	0.5871	0	1	2	3
BDQ23. I am careful what I say	Inhibition of verbal behavior/lack of tact	-0.760	0.074	0.522	1.182	0.8810	0	1	2	3
BDQ22. I can go on a bit	Inhibition of verbal behavior/lack of tact	-0.756	0.100	0.475	0.684	0.9533	0	1	1	2
BDQ17. I talk too much	Inhibition of verbal behavior/lack of tact	-0.708	0.075	0.958	2.747	0.6011	0	1	2	3
BDQ03. It is hard to stop myself from doing things I know I should not do	Inhibition of behaviour/gratification delay	-0.043	0.085	0.745	1.843	0.7646	0	1	2	3
BDQ18. I am open about my sexual feelings towards people	Sexual disinhibition	-0.014	0.105	0.503	12.614	0.0133	0	1	1	2
BDQ01. I say things that people might consider rude	Inhibition of verbal behavior/lack of tact	0.365	0.099	-1.152	7.503	0.1116	0	1	2	3
BDQ19. I am childish	Inhibition of behaviour/gratification delay	0.396	0.117	-1.054	12.081	0.0168	0	1	1	2
BDQ02. I tell people I do not know personal things about myself	Inhibition of verbal behavior/lack of tact	0.461	0.096	-1.360	5.328	0.2553	0	1	2	3
BDQ06. I get over-excited	Sexual disinhibition	0.872	0.105	-1.127	5.753	0.2183	0	1	2	3
BDQ05. I say rude things to people I do not know very well	Inhibition of verbal behavior/lack of tact	0.889	0.123	-1.866	5.965	0.2018	0	1	2	3
BDQ14. I hug and kiss strangers	Sexual disinhibition	0.946	0.140	0.834	4.560	0.3355	0	1	1	2
List of deleted items (in order of deletion from top to bottom)	Conceptual facet	Reasons for deletion				Scoring model				
BDQ11. I feel I have to do things even though I might get into trouble	Inhibition of behaviour/gratification delay	Misfitting (underfitting and significant chi-square), uniform DIF for age and responder, and non-uniform DIF for responder, rescored				0	1	1	2	
BDQ 07. I do what I want	Inhibition of behaviour/gratification delay	Misfitting (underfitting with significant chi-square)				0	1	2	3	
BDQ 12. I wait my turn	Inhibition of behaviour/gratification delay	Local dependency, misfitting (underfitting with significant chi-square), both uniform and non-uniform DIF for responder, rescored				0	1	1	2	
BDQ 20. I can concentrate on what I am doing	Inhibition of behaviour/gratification delay	Misfitting (underfitting)				0	1	2	3	
BDQ 09. It is hard to stop thinking about something I want to do	Inhibition of behaviour/gratification delay	Local dependency and misfitting (significant chi-square)				0	1	2	3	
BDQ 21. I let someone know if I find them attractive	Sexual disinhibition	Local dependency and rescored				0	1	1	2	
BDQ 04. I do things that I know are wrong	Inhibition of behaviour/gratification delay	Local dependency				0	1	2	3	
BDQ 13. It is hard for me to stop myself once I have got an idea into my head	Inhibition of behaviour/gratification delay	Local dependency and misfitting (underfitting with significant chi-square)				0	1	2	3	
BDQ 15. I find it hard to be patient and wait for my turn to speak	Inhibition of verbal behavior/lack of tact	Local dependency and rescored				0	1	1	2	
BDQ 10. I say things that embarrass people	Inhibition of verbal behavior/lack of tact	Local dependency, misfitting (significant chi-square) and rescored				0	1	1	2	
BDQ 08. It is hard to stop myself from doing something once I have thought of it	Inhibition of behaviour/gratification delay	Misfitting (underfitting with significant chi-square) and rescored				0	1	1	2	

Abbreviations: BDQ, BIRT Disinhibition Questionnaire; FR, fit residual; Prob, χ^2 probability; SE, standard error; χ^2 , chi-square.

Notes: The second column from the left contains the conceptual facets identified within the questionnaire: inability to inhibit behavior or to delay gratification, inability to inhibit verbal behavior/lack of tact, and sexual disinhibition. The location is expressed in logits. The degrees of freedom for each χ^2 were 4 for all items. The original scoring pattern for all items was 0 1 2 3. The lower part of the table displays the 11 items which were progressively deleted (from top to bottom) together with the reasons for their deletion.

^aBonferroni-corrected p-value was set at 0.0038, indicative of statistical significance at the 0.05 level.

Table 2e. Item content, fit statistics, and scoring model for the final solution of the BIRT Impulsivity Questionnaire (N=308)

Retained items (increasing difficulty from top to bottom)	Conceptual facet	Item Parameters and Fit Statistics					Scoring Model
		Location	SE	FR	χ^2	Prob ^a	
BIQ08. When I want something it is hard to wait	Acting/speaking on impulse	-1.066	0.076	-0.103	3.912	0.4181	0 1 2 3
BIQ09. I am a calm person	Emotional impulsivity	-0.724	0.080	0.807	7.583	0.1081	0 1 2 3
BIQ24. I rush into things	Lack of planning /Inability to foresee outcome	-0.634	0.082	1.435	4.614	0.3292	0 1 2 3
BIQ14. I change my mind about things	Snap decision making/spontaneity	-0.397	0.096	-0.114	7.512	0.1112	0 1 2 3
BIQ25. I feel restless	Emotional impulsivity	-0.301	0.087	-1.057	9.348	0.0530	0 1 2 3
BIQ30. I do things on the 'spur of the moment'	Snap decision making/spontaneity	-0.290	0.093	-1.317	9.011	0.0608	0 1 2 3
BIQ03. I say things without thinking	Acting/speaking on impulse	-0.085	0.088	-0.622	1.319	0.8581	0 1 2 3
BIQ12. I buy things I do not need	Acting/speaking on impulse	-0.071	0.085	2.095	8.628	0.0711	0 1 2 3
BIQ07. I get angry all of a sudden	Emotional impulsivity	0.095	0.090	-0.769	2.948	0.5666	0 1 2 3
BIQ15. It is hard to stop myself from doing things I am not supposed to	Acting/speaking on impulse	0.138	0.090	-1.338	3.675	0.4517	0 1 2 3
BIQ11. I do not realise that what I'm doing might be dangerous	Lack of planning /Inability to foresee outcome	0.188	0.112	0.924	2.639	0.6199	0 1 1 2
BIQ02. I am good at keeping secrets	Acting/speaking on impulse	0.206	0.112	1.961	11.492	0.0216	0 1 1 2
BIQ28. I get over-excited	Emotional impulsivity	0.569	0.102	-0.429	2.753	0.5999	0 1 2 3
BIQ10. I upset people without realising	Acting/speaking on impulse	0.649	0.100	-1.599	6.389	0.1719	0 1 2 3
BIQ19. I feel 'out of control'	Emotional impulsivity	0.821	0.107	-0.548	2.632	0.6212	0 1 2 3
BIQ16. I spend all of my money as soon as I get it	Lack of planning /Inability to foresee outcome	0.901	0.130	0.379	1.371	0.8492	0 1 1 2
List of deleted items (in order of deletion from top to bottom)	Conceptual facet	Reasons for deletion					Scoring model
BIQ01. I plan ahead	Lack of planning /Inability to foresee outcome	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BIQ20. I make a plan first before I start a task	Lack of planning /Inability to foresee outcome	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BIQ18. It is easy for me to make my mind up about things	Snap decision making/spontaneity	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BIQ22. I do things in a hurry	Acting/speaking on impulse	Local dependency and misfitting (underfitting with significant chi-square)					0 1 2 3
BIQ26. I say things I should not	Acting/speaking on impulse	Local dependency and misfitting (overfitting with significant chi-square)					0 1 2 3
BIQ04. When I have an idea I want to tell people about it straight away	Acting/speaking on impulse	Misfitting (underfitting)					0 1 2 3
BIQ13. I do things without thinking	Acting/speaking on impulse	Local dependency and misfitting (overfitting)					0 1 2 3
BIQ29. I make snap decisions	Snap decision making/spontaneity	Local dependency and misfitting (overfitting)					0 1 2 3
BIQ06. I am careful what I say	Acting/speaking on impulse	Local dependency					0 1 2 3
BIQ27. I buy more than I need	Acting/speaking on impulse	Local dependency					0 1 2 3
BIQ17. I am a relaxed person	Emotional impulsivity	Local dependency and misfitting (significant chi-square)					0 1 2 3
BIQ23. If I see something I like I buy it straight away	Acting/speaking on impulse	Local dependency					0 1 2 3
BIQ05. I blurt things out when I do not mean to	Acting/speaking on impulse	Local dependency and rescored					0 1 1 2
BIQ32. I am a patient person	Emotional impulsivity	Local dependency					0 1 2 3
BIQ31. I think about things carefully before I do them	Acting/speaking on impulse	Misfitting (underfitting)					0 1 2 3
BIQ21. I find it hard to concentrate for a long time	?	Misfitting (significant chi-square)					0 1 2 3

Abbreviations: BDQ, BIRT Disinhibition Questionnaire; FR, fit residual; Prob, χ^2 probability; SE, standard error; χ^2 , chi-square.

Notes: The second column from the left contains the conceptual facets identified within the questionnaire: acting/speaking on impulse, emotional impulsivity, lack of planning/inability to foresee outcomes, and snap decision-making/excessive spontaneity. The location is expressed in logits. The degrees of freedom for each χ^2 were 4 for all items. The original scoring pattern for all items was 0 1 2 3. The lower part of the table displays the 16 items which were progressively deleted together with the reasons for their deletion.

^aBonferroni-corrected p-value was set at 0.0031, indicative of statistical significance at the 0.05 level.

APPENDIX 3

SHORT FORM OF THE “BRAIN INJURY REHABILITATION TRUST PERSONALITY QUESTIONNAIRE” (BIRT-PQ SF)

Patient version

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**‘Less is more’: validation with Rasch analysis of five short-forms
for the Brain Injury Rehabilitation Trust Personality Questionnaires (BIRT-PQs).**

Brain Injury.

Name and Surname:	Administration date:
Diagnosis:	Lesion date:

BIRT-PQ Short Forms – PATIENT version	TOTAL SCORE
MOTIVATION (BMQ-SF19-P)	___/57
EMOTIONAL REGULATION (BREQ-SF17-P)	___/48
SOCIAL COGNITION (BSCQ-SF13-P)	___/34
DISINHIBITION (BDQ-SF13-P)	___/35
IMPULSIVITY (BIQ-SF16-P)	___/45

Please read the following statements. Each statement is followed by a series of possible responses: *always, often, sometimes, never*. Please CIRCLE the response which you consider best fits each statement. Please respond to every statement. If you are not sure which response is the best one, please choose the response which you feel is most appropriate. Do not spend too long on each question. It is essential that you answer each question as honestly as possible.

**MOTIVATION Short Form Questionnaire – PATIENT version
(BMQ-SF19-P)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BMQ02	I leave things until the last minute	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ03	I am late for appointments	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ04	I cannot be bothered to do important things, even though I know I should	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ07	It is hard to decide what I want when people give me choices about things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ08	I make the same mistakes over and over again	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ11	I have lots of ‘get up and go.’	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ12	I avoid doing things I do not have to	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ14	I feel tired	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ15	I get/do things in the wrong order	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ16	It takes longer to finish things these days	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ19	I finish things I start	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ20	It is hard to think of things to do	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ22	I feel confident	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ23	I think of things to do but never get around to doing them	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ25	I feel I have got nothing done all-day	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ26	I am disorganized	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ27	I have doubts about what I can achieve	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ28	I try hard	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ31	I get distracted from what I am doing	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						<u> </u> /57

**EMOTIONAL REGULATION Short Form Questionnaire – PATIENT version
(BREQ-SF17-P)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BREQ01	I have sudden mood swings	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ03	I am unpredictable	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ07	I cannot remember what happens when I lose my temper	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ09	I feel upset for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ10	I get into a rage	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ14	I cry for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ15	I feel tired after I have been in a rage	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ17	I feel anxious for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ19	I do not understand why I am upset	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ20	I am a calm person	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BREQ21	I sulk when I have been in a bad mood	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ22	It is hard for people to get through to me when I am upset	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ23	I break things I value when I am in a temper	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ27	When I get into a rage, everything becomes a blur	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ30	I get upset	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ31	When I am angry, I do not understand why	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ32	I snap at people	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						<u> </u> /48

**SOCIAL COGNITION Short Form Questionnaire – PATIENT version
(BSCQ-SF13-P)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BSCQ01	I feel left out of conversations	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ03	People misunderstand me	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ04	I find it hard to understand people on the telephone	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ06	I find it hard to imagine things in the future	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ09	I am amusing	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ10	I find it hard to make friends	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ11	I am relaxed around other people	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ12	I find it hard to tell how people feel	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ16	I prefer being on my own than with others	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ20	I feel comfortable in social situations	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ24	People get cross with me for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ27	I enjoy other people's company	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ28	I get confused when talking in a group of people	Never (0)	Sometimes (1)	Often (1)	Always (2)	
TOTAL SCORE						___/34

**DISINHIBITION Short Form Questionnaire – PATIENT version
(BDQ-SF13-P)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BDQ01	I say things that people might consider rude	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ02	I tell people I do not know personal things about myself	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ03	It is hard to stop myself from doing things I know I should not do	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ05	I say rude things to people I do not know very well	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ06	I get over-excited	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ14	I hug and kiss strangers	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ16	It is hard not to say something once I have thought of it	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ17	I talk too much	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ18	I am open about my sexual feelings towards people	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ19	I am childish	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ22	I can go on a bit	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ23	I am careful what I say	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BDQ24	I can hold back my feelings	Never (3)	Sometimes (2)	Often (1)	Always (0)	
TOTAL SCORE						___/35

**IMPULSIVITY Short Form Questionnaire – PATIENT version
(BIQ-SF16-P)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BIQ02	I am good at keeping secrets	Never (2)	Sometimes (1)	Often (1)	Always (0)	
BIQ03	I say things without thinking	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ07	I get angry all of a sudden	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ08	When I want something, it is hard to wait	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ09	I am a calm person	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BIQ10	I upset people without realizing	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ11	I do not realize that what I'm doing might be dangerous	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BIQ12	I buy things I do not need	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ14	I change my mind about things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ15	It is hard to stop myself from doing things I am not supposed to	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ16	I spend all of my money as soon as I get it	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BIQ19	I feel 'out of control.'	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ24	I rush into things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ25	I feel restless	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ28	I get over-excited	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ30	I do things on the 'spur of the moment'	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						___/45

APPENDIX 4

SHORT FORM OF THE “BRAIN INJURY REHABILITATION TRUST PERSONALITY QUESTIONNAIRE” (BIRT-PQ SF)

Caregiver version

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**'Less is more': validation with Rasch analysis of five short-forms
for the Brain Injury Rehabilitation Trust Personality Questionnaires (BIRT-PQs).**

Brain Injury.

Name and Surname:	Administration date:
Diagnosis:	Lesion date:

BIRT-PQ Short Forms – CAREGIVER version	TOTAL SCORE
MOTIVATION (BMQ-SF19-C)	____/57
EMOTIONAL REGULATION (BREQ-SF17-C)	____/48
SOCIAL COGNITION (BSCQ-SF13-C)	____/34
DISINHIBITION (BDQ-SF13-C)	____/35
IMPULSIVITY (BIQ-SF16-C)	____/45

Please read the following statements thinking about your relative. Each statement is followed by a series of possible responses: *always, often, sometimes, never*. Please CIRCLE the response which you consider best fits each statement. Please respond to every statement. If you are not sure which response is the best one, please choose the response which you feel is most appropriate. Do not spend too long on each question. It is essential that you answer each question as honestly as possible.

**MOTIVATION Short Form Questionnaire – CAREGIVER version
(BMQ-SF19-C)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BMQ02	He/she leaves things until the last minute	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ03	He/she is late for appointments	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ04	He/she cannot be bothered to do important things, even though he/she knows he/she should	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ07	It is hard to decide what he/she wants when people give him/her choices about things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ08	He/she makes the same mistakes over and over again	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ11	He/she has lots of 'get up and go.'	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ12	He/she avoids doing things he/she does not have to	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ14	He/she feels tired	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ15	He/she gets/does things in the wrong order	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ16	He/she takes longer to finish things these days	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ19	He/she finishes things he/she starts	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ20	It is hard for him/her to think of things to do	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ22	He/she feels confident	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ23	He/she thinks of things to do but never get around to doing them	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ25	He/she feels he/she have got nothing done all-day	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ26	He/she is disorganized	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ27	He/she has doubts about what he/she can achieve	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BMQ28	He/she tries hard	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BMQ31	He/she gets distracted from what He/she is doing	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						<u> </u> /57

**EMOTIONAL REGULATION Short Form Questionnaire – CAREGIVER version
(BREQ-SF17-C)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BREQ01	He/she has sudden mood swings	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ03	He/she is unpredictable	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ07	He/she cannot remember what happens when he/she loses my temper	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ09	He/she feels upset for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ10	He/she gets into a rage	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ14	He/she cries for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ15	He/she feels tired after he/she has been in a rage	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ17	He/she feels anxious for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ19	He/she does not understand why he/she is upset	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ20	He/she is a calm person	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BREQ21	He/she sulks when he/she has been in a bad mood	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ22	It is hard for people to get through to him/her when he/she is upset	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ23	He/she breaks things he/she values when he/she is in a temper	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BREQ27	When he/she gets into a rage, everything becomes a blur	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ30	He/she gets upset	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ31	When he/she is angry, he/she does not understand why	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BREQ32	He/she snaps at people	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						<u> </u> /48

**SOCIAL COGNITION Short Form Questionnaire – CAREGIVER version
(BSCQ-SF13-C)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BSCQ01	He/she feels left out of conversations	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ03	People misunderstand him/her	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ04	He/she finds it hard to understand people on the telephone	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ06	He/she finds it hard to imagine things in the future	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ09	He/she is amusing	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ10	He/she finds it hard to make friends	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ11	He/she is relaxed around other people	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ12	He/she finds it hard to tell how people feel	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ16	He/she prefers being on him/her own than with others	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BSCQ20	He/she feels comfortable in social situations	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ24	People get cross with him/her for no reason	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BSCQ27	He/she enjoys other people's company	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BSCQ28	He/she gets confused when talking in a group of people	Never (0)	Sometimes (1)	Often (1)	Always (2)	
TOTAL SCORE						___/34

**DISINHIBITION Short Form Questionnaire – CAREGIVER version
(BDQ-SF13-C)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BDQ01	He/she says things that people might consider rude	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ02	He/she tells people he/she does not know personal things about himself/herself	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ03	It is hard to stop himself/herself from doing things he/she knows he/she should not do	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ05	He/she says rude things to people he/she does not know very well	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ06	He/she gets over-excited	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ14	He/she hugs and kisses strangers	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ16	It is hard not to say something once he/she has thought of it	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ17	He/she talks too much	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BDQ18	He/she is open about him/her sexual feelings towards people	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ19	He/she is childish	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ22	He/she can go on a bit	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BDQ23	He/she is careful about what he/she says	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BDQ24	He/she can hold back him/her feelings	Never (3)	Sometimes (2)	Often (1)	Always (0)	
TOTAL SCORE						<u> </u> /35

**IMPULSIVITY Short Form Questionnaire – CAREGIVER version
(BIQ-SF16-C)**

N°	Item description	Never	Sometimes	Often	Always	Assigned score
BIQ02	He/she is good at keeping secrets	Never (2)	Sometimes (1)	Often (1)	Always (0)	
BIQ03	He/she says things without thinking	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ07	He/she gets angry all of a sudden	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ08	When he/she wants something, it is hard to wait	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ09	He/she is a calm person	Never (3)	Sometimes (2)	Often (1)	Always (0)	
BIQ10	He/she upset people without realizing it	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ11	He/she does not realize that what he/she is doing might be dangerous	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BIQ12	He/she buys things he/she does not need	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ14	He/she changes him/her mind about things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ15	It is hard to stop himself/herself from doing things he/she is not supposed to	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ16	He/she spends all of his/her money as soon as I get it	Never (0)	Sometimes (1)	Often (1)	Always (2)	
BIQ19	He/she feels ‘out of control.’	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ24	He/she rushes into things	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ25	He/she feels restless	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ28	He/she gets over-excited	Never (0)	Sometimes (1)	Often (2)	Always (3)	
BIQ30	He/she does things on the ‘spur of the moment.’	Never (0)	Sometimes (1)	Often (2)	Always (3)	
TOTAL SCORE						___/45