

Factor Structure and Reliability of the Brain Impairment Behavior Scale

Jill I. Cameron, Angela M. Cheung, David L. Streiner, Peter C. Coyte, Mina D. Singh, Donna E. Stewart

Abstract: Stroke is a leading cause of adult disability because of its physical and cognitive consequences. Cognitive changes are important contributors to family caregivers' experiences of emotional distress. To date, measures to assess cognition treat it as a global construct, but it is more likely that unique domains differentially affect family caregivers. The research objectives in this study were to: (1) identify the different domains of cognitive changes in the form of behavioral and psychological symptoms after stroke, and (2) establish the reliability of the Brain Impairment Behavior Scale (BIBS) in measuring cognitive domains. Family caregivers of stroke survivors ($N = 300$) completed the BIBS as part of cross-sectional and longitudinal studies. A subsample of caregivers completed the BIBS twice, 2 weeks apart, to examine the scale's test-retest reliability. We used exploratory factor analysis to identify four domains of behavioral and psychological symptoms in the BIBS: apathy, depression/emotional distress, comprehension/memory problems, and irritability. Internal consistency for the subscales representing each identified domain ranged from .78 to .91, and the 2-week intra-class correlation coefficients ranged from .75 to .88. Future research and clinical use of this measure will increase our understanding of how specific domains of stroke survivors' behavioral and psychological symptoms affect the well-being of family caregivers.

Stroke is a leading cause of adult disability (Raina, Dukeshire, Lindsay, & Chambers, 1998). In addition to the physical difficulties that can last well into the first year after a stroke (Mayo, Wood-Dauphinee, Cote, Durcan, & Carlton, 2002), stroke is also commonly associated with cognitive changes (Desmond et al., 2000). Behavioral and psychological symptoms are thought to represent the "outward

manifestation of some underlying cognitive, psychological, or physiological deficit regardless of origin" (Gauthier, Baumgarten, & Becker, 1996, p. 325). These symptoms can have a profound effect on the emotional well-being of family caregivers who provide essential support to stroke survivors when they return home (Anderson, Linto, & Stewart-Wynne, 1995; Cameron, Cheung, Streiner, Coyte, & Stewart, 2006; Draper, Poulos, Cole, Poulos, & Ehrlich, 1992; Kinney, 1995; White, Poissant, Cote-LeBlanc, & Wood-Dauphinee, 2006). As a result, stroke survivor rehabilitation and the sustainability of home care can be threatened. Therefore, it is important to identify behavioral and psychological symptoms in stroke survivors.

Measures that examine the relationship between cognitive changes and family caregivers' health were developed for psychiatric (Anderson et al., 1995) and elderly populations (Draper et al., 1992). Because these measures were not developed or tested with a population of caregivers of stroke survivors, the measures may not capture the uniqueness of stroke survivors' symptoms and, therefore, could underestimate the occurrence of those symptoms. In addition, previous research commonly viewed behavioral and psychological symptoms as a global construct (Anderson et al.; Draper et al.; Kinney, 1995; Schulz, Tompkins, & Rau, 1988). Yet it is more likely that distinct aspects or domains of symptoms differentially affect caregiver outcomes.

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The Brain Impairment Behavior Scale (BIBS) was developed to identify the presence of behavioral and psychological symptoms in the stroke population as assessed by family caregivers (Williams, 1994; Williams & Dahl, 2002). In this article, we examine the psychometric properties of BIBS. Specifically, we identified the underlying domains of behavioral and psychological symptoms captured by the scale and determined the measure's internal consistency and stability over time.

Methods

Measure

The BIBS was developed through literature review, clinical experience, and consultation with family caregivers of stroke survivors (Williams, 1994; Williams & Dahl, 2002). Preliminary research by Williams, using a sample of 26 family caregivers of stroke survivors, identified some infrequently endorsed items and some complex items (e.g., asking two questions within one item). We revised the measure by removing the infrequently endorsed items, simplifying the complex items, and adding eight new items from the literature and four items from clinical experience to yield a 37-item scale (Fig. 1; Cameron, 2004). Some of the new items were "becomes uncooperative," "becomes suspicious or accusing," "becomes fearful and afraid," and "gets depressed." Family caregivers, who have frequent contact with the stroke survivors and therefore have ample opportunities to observe them, were asked in a structured interview to answer, for each item, "How often during the past 2 weeks did you observe the care receiver behaving this way?" Responses ranged from 1 (*never*) to 5 (*all the time*). Higher scores indicated more frequent behavioral and psychological symptoms as perceived by family caregivers. To support data collection with the French-speaking participants in Montreal, the measure was translated into French by using the forward and backward translation approach (Bullinger et al., 1998).

Participants

Family caregivers were defined as the people who, without financial compensation, were primarily responsible for providing or coordinating the stroke survivors' care in the home. Caregivers were included if they spoke English or French well enough to participate in the structured interview. All caregivers provided written informed consent, and participating institutions' research ethics boards approved the study protocol.

Participants for the factor analysis and estimations of internal consistency were selected from three studies. An ongoing longitudinal cohort study of fam-

ily caregivers of first-time stroke survivors recruited through teaching hospitals in the Canadian cities of Montreal, Toronto, and London provided the first sample (longitudinal cohort). The clinical team, using standard diagnostic criteria, confirmed the stroke diagnosis. Caregivers participated in structured interviews at 1, 3, 6, and 12 months after the care recipient's stroke. To obtain a cross-sectional sample for the factor analysis, caregivers were randomly selected, without replacement, from the 3-month ($n = 58$), 6-month ($n = 54$), and 12-month ($n = 46$) assessments. To increase the range of observable behavioral and psychological symptoms,

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we included two additional samples of family caregivers of patients who may have had more severe strokes (i.e., those who receive inpatient rehabilitation, community care services, or both). The first of these samples consisted of a convenience sample of 94 family caregivers recruited from a rehabilitation hospital, a tertiary care stroke outpatient clinic, and six regional home-care services between 2000 and 2001 (convenience sample 1). Family caregivers were included if the recorded reason for admission was stroke. The second of these samples was a convenience sample of 48 family caregivers recruited between 1998 and 1999 from a tertiary care stroke outpatient clinic (convenience sample 2). Our total sample consisted of 300 family caregivers, representing a subject-to-item ratio of 8:1, which is larger than the recommended minimum ratio of 5:1 (Norman & Streiner, 2000). Participation rates for the three samples ranged from 66% to 85%.

To examine the stability of the BIBS over time, a convenience sample of family caregivers was obtained from two sources. The first source included participants from our longitudinal cohort study who were readministered the revised BIBS (BIBS-R) 2 weeks after their regularly scheduled interview. The second source was from the rehabilitation hospital outpatient clinic and day hospital. Clinical team members identified family caregivers who were asked to complete the BIBS-R by telephone on two occasions, 2 weeks apart. The 2-week separation was chosen because it was considered unlikely that respondents would remember their first set of answers after a 2-week period and because it was

likely that only small to negligible changes in behavior would occur during that time period (Streiner & Norman, 1995).

Analyses

Three types of analyses were conducted for this study: (1) exploratory factor analysis, (2) internal consistency reliability, (3) and test-retest reliability. Before the factor analysis was conducted, the data were examined to ensure the factorability of the items (Norman & Streiner, 2000).

Principal axis factoring identified the underlying factor structure (Russell, 2002). Unrotated, orthogonal (varimax), and oblique (promax) rotations were compared to determine which provided the best fit for the data. The following three methods were used to determine the number of factors: Kaiser's criterion (eigenvalue >1; Norman & Streiner, 2000); Cattell's scree plot (the number of factors on the line's diagonal; Norman & Streiner); and the additional criterion that retained factors had to have at least three items, which is the minimum number of items recommended for a subscale (Russell). Using the formula $CV = 5.152/\sqrt{(n - 2)}$, the critical value for factor loadings was determined and items below this value were deleted (Norman & Streiner). With a sample of 300, the critical value was .30. Items were also deleted if they were complex (i.e., they had loadings of a similar magnitude on more than one factor after rotation).

We examined two aspects of reliability: the internal consistency, and the ability of the BIBS to remain stable over the 2-week period of time when no changes to behavior would be expected (Atkinson, 1982; Duncan et al., 1999). Cronbach's alpha determined the internal consistency for the total sample and for the convenience and longitudinal cohort samples. The two-way random-effects intra-class correlation coefficient (ICC), an indicator of test-retest reliability, determined the stability of the scale over a 2-week period.

Results

Responses from three groups of family caregivers of stroke survivors ($N = 300$) were included in the exploratory factor analysis (Table 1). The combined groups (i.e., longitudinal cohort, convenience sample 1, and convenience sample 2) differed with respect to caregivers' ages and caregivers' mean ratings of behavioral and psychological symptoms observed in stroke survivors. Specifically, participants in convenience sample 2 were younger, on average, than the people in the other samples, and the longitudinal cohort sample reported fewer behavioral and psychological symptoms than the others did. The three combined groups did not differ with respect to the proportions of women or spouses. Thirty-seven caregivers participated in the test-retest reliability study (23 from the longitudinal

Fig 1. Brain Impairment Behavior Scale—Revised
(continued)

26. The care receiver becomes suspicious or accusing.	1	2	3	4	5
	never				all the time
27. *The care receiver becomes fearful and afraid.	1	2	3	4	5
	never				all the time
28. The care receiver does not know who you are.	1	2	3	4	5
	never				all the time
29. *The care receiver repeats questions/stories.	1	2	3	4	5
	never				all the time
30. The care receiver has trouble speaking.	1	2	3	4	5
	never				all the time
31. *The care receiver worries unnecessarily.	1	2	3	4	5
	never				all the time
32. *The care receiver gets depressed.	1	2	3	4	5
	never				all the time
33. The care receiver endangers him/herself.	1	2	3	4	5
	never				all the time
34. Things people say bother the care receiver.	1	2	3	4	5
	never				all the time
35. *The care receiver loses track of time.	1	2	3	4	5
	never				all the time
36. The care receiver does not try very hard.	1	2	3	4	5
	never				all the time
37. The care receiver wants to be with someone all the time.	1	2	3	4	5
	never				all the time

cohort and 14 from a rehabilitation facility). These 37 caregivers differed in age and sex compared to the participants in the exploratory factor analysis (Table 1). Specifically, participants in the test-retest reliability sample were more likely to be female, to be younger, and to report fewer behavioral and psychological symptoms than the groups included in the factor analysis.

Table 1. Caregiver Characteristics

Variable	Longitudinal Cohort (<i>n</i> = 158)	Convenience Sample 1 (<i>n</i> = 94)	Convenience Sample 2 (<i>n</i> = 48)	Test-Retest (<i>n</i> = 37)	Test Statistic	<i>p</i>
Age*	59.9 ^b (14.35)	60.8 ^b (15.41)	54.6 ^a (16.63)	54.1 ^a (18.00)	2.9	.03
Female [†]	103 ^a (73%)	74 ^a (79%)	36 ^a (75%)	20 ^b (54%)	8.3	.04
Spouse [†]	98 (69%)	62 (66%)	31 (65%)	24 (65%)	.4	.94
BIBS-R 37-item [‡]	1.6 ^b (.57)	2.1 ^a (.71)	2.1 ^a (.55)	N/A	24.4	.001
BIBS-R 18-item [‡]	1.7 ^c (.66)	2.3 ^b (.80)	2.2 ^{a,b} (.74)	1.9 ^{a,c} (.77)	15.3	.001

Note. N/A = not available.
^{a,b,c} Non-overlapping superscripts indicate significant group differences ($p < .05$) according to post-hoc comparisons (Tukey B for age and BIBS-R 37 and BIBS-R 18) and two-by-two chi-square analysis (female and spouse).
^{*}Mean (SD), *F* statistic; [†]Number (percentage), chi-square statistic; [‡]Mean (SD) rating across the 37 and 18 items from the original and revised Brain Impairment Behavior Scale (BIBS-R), *F* statistic.

Factor Analysis

A large overall measure of sampling adequacy (.93), a significant Bartlett's Test of Sphericity (χ^2 (465) = 4891.76, $p < .001$), and more than half (57%) of the inter-item correlations were significant, supporting the factorability of the items. There was a minimal amount of missing data (<0.3%), and these items were replaced by the median for each item. Examination of the data revealed that many of the items were positively skewed and, therefore, were transformed. The skew of six items ("loses way around," "blames others," "becomes violent," "becomes suspicious," "doesn't know who you are," "endangers him/herself") did not decrease after transformation. The *never* response option was selected more than 80% of the time for these six items, suggesting that those behaviors were very uncommon in this population; therefore, these items were excluded from the analysis. The factor analyses were run with and without transforming the remaining 31 items. The results did not differ (i.e., the same items loaded on the same factors with similar-sized loadings), so the results using the untransformed data are presented.

Examination of the eigenvalues and scree plots from the unrotated factor solution suggested seven factors. Only four of the factors had three or more noncomplex items with loadings above the critical value (i.e., >.30). Preliminary rotated solutions suggested that the oblique rotation achieved the best fit to the data. Therefore, a four-factor oblique rotation solution was forced. These results suggested deletion of five complex items and eight items with low loadings. After these items were removed and the analyses were rerun, the final results identified 18 noncomplex items with loadings above the critical value, including three factors with five items each and one factor with three items (Table 2). The factor correlation matrix supported the use of an

oblique rotation, as the between-factor correlations ranged from .53 to .63.

The four factors were named apathy, comprehension/memory problems, depression/emotional distress, and irritability. These factors explained 56.3% of the variance, as outlined in Table 2. The mean ratings on the derived factors ranged from 2.3 ($SD = .92$) for the depression/emotional distress factor to 1.7 ($SD = .84$) for the comprehension/memory problems factor.

Systematic differences were observed in the characteristics of the samples combined for the purposes of these analyses. We performed two separate factor analyses with the 18-item measure, in the two convenience samples combined and in the longitudinal cohort sample. The same items loaded on the same factors with similar-sized loadings in the combined convenience sample ($n = 142$). In the longitudinal cohort sample, the loading of one item, "gets tired," moved from the third (depression/emotional distress) to the first (apathy) factor. In addition, four items had second loadings between .30 and .35, but the loading on their primary factor remained the dominant and considerably larger loading (e.g., .65 versus .35). As a result, the factor structure identified by the full sample is presented as the final structure.

Reliability

The subscales' internal consistency and test-retest reliability are reported in Table 3. The levels of internal consistency were maintained when examined separately in the combined convenience and longitudinal cohort samples.

Discussion

The results of the factor analysis and reliability testing of the revised BIBS are encouraging. The

Table 2. Rotated Factor Pattern for Final 18-Item Brain Impairment Behavior Scale

Item	Item Rating ^a	Factor Loading by Rotated Factor Pattern			
		1 (Apathy)	2 (Comprehension/ Memory Problems)	3 (Depression/ Emotional Distress)	4 (Irritability)
Has no interest in anything	1.9	.901			
Does not want to do anything	2.0	.887			
Just sits and watches	1.8	.794			
Has difficulty becoming interested in things	1.9	.732			
Waits for someone to do things he or she could do	1.8	.723			
Has difficulty thinking clearly	2.0		.789		
Loses track of time	1.6		.752		
Shows poor judgment	1.6		.650		
Does not understand information	1.7		.644		
Repeats questions/stories	1.7		.548		
Gets depressed	2.5			.718	
Becomes fearful/afraid	1.8			.662	
Cries easily	1.6			.647	
Worries unnecessarily	2.1			.512	
Gets tired easily	3.6			.414	
Loses temper easily	2.0				.866
Is impatient	2.3				.764
Becomes uncooperative	1.5				.404
Eigenvalue		7.6	1.6	1.4	1.2
Percentage of variance		40.1	6.7	5.2	4.3
Percentage of rotated variance		6.0	5.3	4.6	4.3
Mean rating		1.9	1.7	2.3	1.9
SD		1.01	.84	.92	.99

Note. Factor loadings less than .25 are not shown.

^aMean rating for each item on 1–5 scale.

exploratory factor analysis identified four underlying domains of behavioral and psychological symptoms commonly exhibited after stroke, and these domains can be used as subscales of the BIBS-R. The domains were apathy, comprehension/memory problems, depression/emotional distress, and irritability. Symptoms that characterize each domain can be seen in Table 2.

The oblique rotation provided the best fit to our data, suggesting that these domains of poststroke behavioral and psychological symptoms are inter-related. The subscales were internally consistent in the overall sample as well as in the convenience samples and longitudinal samples. Test-retest reliability also indicated that the subscales were stable during a 2-week period. The observed internal consistency and stability during the 2-week period were consistent with Williams' findings (Williams & Dahl, 2002) and those of other behavioral rating scales (Cummings et al., 1994; Teri et al., 1992).

Behavioral and psychological symptoms also are common in Alzheimer disease, and symptom impact

on family caregivers of Alzheimer patients has been more frequently studied (Gerdner, Buckwalter, & Reed, 2002; Pang et al., 2002). In fact, the similarities in symptoms between stroke and Alzheimer disease are making stroke experts suggest that the two fields should be studied together, as they may have common underlying processes and therefore may benefit from common treatment approaches (Hachinski, 2003). Our findings have similarities to measures used in Alzheimer disease research. Specifically, our results identified domains in common with Alzheimer disease measures, including depression or mood (Frisoni et al., 1999; Tariot et al., 1995; Teri et al., 1992), apathy (Tariot et al.), irritability (Tariot et al.), and memory problems (Teri et al.).

It is also important to account for the factors that we did not obtain in our analysis but that have appeared in the Alzheimer literature. The disruption domain identified by Teri and colleagues (1992) was not evident in our analysis, even though the 37-item BIBS-R contains similar questions. It appears that these behaviors (e.g., "becomes violent," "endangers

Table 3. Reliability of the Subscales of the 18-Item Brain Impairment Behavior Scale

Subscale	Internal Consistency [†]			Test-Retest Reliability [‡] (n = 37)
	Convenience Samples (n = 142)	Longitudinal Cohort (n = 158)	Total Sample (N = 300)	
Apathy	.91	.89	.91	.75
Comprehension/Memory Problems	.80	.83	.83	.88
Depression/Emotional Distress	.72	.75	.78	.82
Irritability	.80	.74	.78	.81

[†]Cronbach's alpha; [‡]Two-way random-effects intra-class correlation coefficient.

him/herself") are less common in stroke, as they were infrequently reported by caregivers in this study and, as a result, the corresponding items were deleted from the analyses. Other scales have identified a psychotic domain, which includes hallucinations, misidentification, agitation, and delusions (Frisoni et al., 1999; Tariot et al., 1995). Again, items from this domain (e.g., "becomes suspicious," "does not know who you are") were deleted from analysis because caregivers in our sample reported these symptoms infrequently.

The BIBS-R, developed and tested in a population of caregivers of stroke survivors, has many advantages for use in stroke research. The domains of behavioral and psychological symptoms were identified by the rigorous methods of factor analysis in a large, diverse sample of family caregivers. The subscales displayed internal consistency and stability over time.

Clinical Implications

Healthcare professionals can administer the 18-item scale to family caregivers who, because of their frequent contact with the stroke survivor, can easily identify changes in the survivor's behavioral and psychological well-being. This information can guide additional clinical assessment and, potentially, clinical care as stroke survivors' progress is monitored during their recovery and rehabilitation. In addition, awareness of the level of behavioral and psychological impairment in the stroke survivor can inform discharge planning. Caregivers can be educated about behavioral and psychological changes after stroke and taught strategies to manage those changes. Education of caregivers is crucial to ensure sustainability of home care for the stroke survivor, and to promote the highest quality of life and positive outcomes for both the stroke survivor and the caregivers.

Limitations

The low individual item mean scores (ranging from 1.5 to 3.6) suggest that there may be a floor effect, with our caregivers infrequently observing behavioral and psychological symptoms in their family members. This also contributed to the skewness of

the data. Therefore, one limitation of this research was the exclusion of stroke survivors residing in long-term care facilities. Patients residing in long-term care facilities are more likely to have cognitive impairment (Gray, Farish, & Dorevitch, 1992; Rockwood, Stolee, & McDowell, 1996). Therefore, it is possible that patients in that population would have exhibited some of the symptoms that were infrequently reported in our sample (e.g., "loses his or her way around," "becomes suspicious"). Future work is needed to replicate this factor structure in an independent sample. The items in the revised BIBS explained 56.3% of the variance, suggesting that there may be additional behavioral changes not captured in the scale. Future qualitative research with family caregivers of stroke survivors may identify additional behavioral and psychological changes. In addition, examining the extent to which these behaviors are perceived as bothersome by family caregivers may further our understanding of how behavioral and psychological symptoms affect family caregivers' experiences and well-being.

Summary

In our large sample of family caregivers of stroke survivors, we identified four domains of behavioral and psychological symptoms. These subscales were internally consistent and stable over time. Family caregivers, who spend a considerable amount of time with stroke survivors, could be assessed using this measure to provide healthcare professionals with insight into any changes in the behavioral and psychological well-being of the stroke survivors. Finally, by identifying the specific domains that have a larger impact, this scale can be used to further our understanding of how stroke survivors' behavioral and psychological symptoms affect family caregiver well-being. This information can contribute to the development of interventions and programs aimed at enhancing the health and well-being of family caregivers.

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