Published in final edited form as:
Arch Phys Med Rehabil. 2012 January ; 93(1): 137–142. doi:10.1016/j.apmr.2011.06.036.

Psychometric Evaluation of Neglect Assessment Reveals Motor-Exploratory Predictor of Functional Disability in Acute-Stage Spatial Neglect

Kelly M. Goedert, Ph.D.[1], **Peii Chen, Ph.D.**[2,3,4], **Amanda Botticello, Ph.D.**[2,3], **Jenny R. Masmela, B.A.**[2], **Uri Adler, M.D.**[3,6], and **Anna M. Barrett, M.D.**[2,3,4,5,6]

[1] Department of Psychology, Seton Hall University, South Orange, NJ

[2] Kessler Foundation Research Center, West Orange, NJ;

[3] Department of Physical Medicine & Rehabilitation, University of Medicine and Dentistry of New Jersey – New Jersey Medical School (UMDNJ-NJMS), Newark, NJ

[4] Graduate School of Biomedical Sciences, UMDNJ-NJMS

[5] Department of Neurology and Neuroscience, UMDNJ-NJMS

[6] Kessler Institute for Rehabilitation, Saddle Brook, NJ

Abstract

Objective—Spatial neglect is a failure or slowness to respond, orient, or initiate action towards contra-lesional stimuli, associated with functional disability that impedes stroke recovery. Early identification of specific neglect deficits may identify patients likely to experience chronic disability. However, psychometric evaluation of assessments has focused on subacute/chronic populations. We addressed this gap by assessing two neglect measures – the Behavioral Inattention Test (BIT) and the Catherine Bergego Scale (CBS) – in *acute* neglect.

Design—Correlational/Psychometric study.

Setting—Inpatient rehabilitation hospital.

Participants—Screening identified 51 consecutive right-hemisphere stroke patients with left neglect (BIT conventional score < 129 or CBS > 11) that tested an average of 22.3 days post-stroke.

Interventions—Not applicable.

Main Outcome Measures—We obtained BIT, CBS, and Barthel assessments for each participant, and clinical and laboratory measures of perceptual-attentional and motor-intentional deficits.

Results—The BIT demonstrated good reliability and loaded onto a single factor. Consistent with our theoretical prediction, principal components analysis of the CBS identified two underlying factors: “Where” perceptual-attentional items (CBS-PA) and embodied, motor exploratory items

Corresponding Author: Kelly M. Goedert, Department of Psychology, Seton Hall University, 400 South Orange Ave., South Orange, NJ 07079, Office Phone: 973-275-2703, Fax: 973-275-5852, Cell Phone: 551-208-9992, kelly.goedert@shu.edu.

Presentation of Work: A portion of this work was presented in abstract form at the 39th annual meeting of the International Neuropsychological Society (February, 2010, Boston, MA).

Financial Disclosures: The authors certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated, and we certify that all financial and material support for this research (eg, NIH or NHS grants) and work are clearly identified in the title page of the manuscript.

(CBS-ME). The CBS-ME uniquely predicted ADL deficits (Barthel Index), but did not predict clinical and laboratory assessments of motor-intentional bias. More severe neglect on CBS-PA correlated with greater "Where" perceptual-attentional bias on clinical and laboratory tests, but did not uniquely predict deficits in activities of daily living (ADLs).

Conclusions—Our results indicate that assessments of spatial neglect may be used to detect specific motor-exploratory deficits in spatial neglect. Obtaining CBS-ME scores routinely might improve detection of acute stage patients with spatial action deficits requiring increased assistance that may persist to the chronic stage.

Keywords

stroke; psychometrics; neglect; assessment

Spatial neglect, a functionally disabling failure or slowness to respond, orient, or initiate action towards contra-lesional stimuli,[1,2] impairs stroke rehabilitation and recovery.[3] In acute stroke, neglect may better predict the extent of right-brain stroke damage than does the NIH Stroke Scale.[4] Acute-stage neglect detection and intervention may improve the recovery prospects of affected patients,[3,5] potentially saving hundreds of thousands of dollars in acute-care costs annually.[6] Unfortunately, neglect is under-identified and under-assessed acutely.[7]

Two promising instruments for neglect assessment

Two tests appear appropriate for reliable and valid neglect assessment. The Behavioral Inattention Test-conventional (BIT)[8] is a 6-item paper-and-pencil test with established test-retest reliability in subacute patients (2 to 18 months post-event).[9] The test has validly discriminated among controls and left and right brain-damaged patients, and is related to performance of activities of daily living.[9] Further, it proved unidimensional (i.e., assessing a single factor) in a sample of subacute and chronic patients.[8] Recent psychometric assessment of the BIT, using dichotomized versions of the sub-test scores, revealed inadequate reliability[11] in an acute sample (< 2 mo. post-event). However, a shortened version proved reliable and unidimensional.

The Catherine Bergego Scale (CBS)[12] is a 10-item instrument typically completed by a therapist after observing a patient perform common activities such as grooming and eating (e.g., patients with left neglect may fail to groom the left side of the face). Psychometric assessments of the CBS in subacute and chronic right-brain damaged patients revealed good internal consistency, validity (i.e., predictive of activities of daily living),[12] and unidimensionality.[13]

Differing Patterns of Dysfunction

Both the BIT and CBS can be used to detect neglect. However, the brain-behavior dysfunction responsible for spatial errors may occur at more than one stage of cognitive processing: classically, patients are expected to experience selective disability in perceptual-attentional "Where" systems, displaying a profound difficulty perceiving and attending to contra-lesional stimuli. However, patients may also make motor-intentional "Aiming" spatial errors, displaying difficulty initiating actions towards or in the contra-lesional side of space.[1,14,15,16] Some research suggests that a motor-intentional component may underlie chronic disability in neglect.[17]

Current Study

Although the psychometric properties of the BIT and CBS are established for subacute and chronic populations, [9,10,11,12,13] their properties at the *acute* stage of post-stroke recovery are still largely undetermined. These tests may not demonstrate the same properties at the acute stage. In particular, if the BIT or CBS allowed the examiner to assess distinct perceptual "Where" or motor-intentional "Aiming" components of spatial errors at the acute stage, it might help identify patients most likely to have persistent disability[17] and help to triage patients for targeted treatment plans.[18]

We explored the factor structure of the BIT-conventional and CBS in an acute (< 2 mo. post-stroke) left neglect population. Additionally, we considered that BIT-conventional and CBS items might assess similar latent constructs and thus, performed combined principal components analysis (PCA) of the two tests. Finally, to determine the validity of any identified components, we assessed relations among the BIT, CBS, and clinical assessments of perceptual-attentional (double-simultaneous stimulation) and motor-intentional dysfunction (lateralized motor performance), as well as their relation to a laboratory line bisection task used to decouple "Where" and "Aiming" errors.[2,14]

METHOD

This research was approved by the Institutional Review Board. A consecutive sample of 57 acute right-hemisphere stroke patients from inpatient rehabilitation facilities met the inclusion criteria, gave informed consent and completed left neglect screening. Eligible patients were pre-morbidly right-handed,[19] had no previous neurological damage or psychiatric conditions, and were not currently taking psychiatric medication. Screening identified 51 participants (27 female) with left neglect (BIT conventional score < 129 or CBS > 11), who were retained for analysis (see Table 1 for participant characteristics). All participants were assessed on the CBS and BIT-conventional. Subsets of participants received additional testing.

Behavioral Inattention Test-Conventional (BIT), *N*=51

The BIT-Conventional[8] consists of six sub-tests: line crossing, letter cancellation, star cancellation, figure/shape copying, line bisection and representational drawing (see Halligan et al.[9] for description). Higher scores on the BIT indicate better functioning (range 0 to 146).

Catherine Bergego Scale (CBS), *N*=51

The CBS[12] is a 10-item scale reflecting therapists' ratings of participants' performance for stimuli and actions to the left (for complete text of items see Azouvi et al[12]). Items are scored on a 0 to 3 scale of severity, with *0* indicating *no neglect* and *3* indicating *severe neglect*. Lower scores on the CBS indicate better functioning (range 0 to 30).

Barthel Index, *N*=49

The Barthel Index, completed by participants' nurses and therapists, assesses participants' independence in activities of daily living. Higher scores indicate greater independence (range 0 to 100).

Lateralized Motor Performance (LMP), *N*=29

We created an assessment of hemispatial hypokinesia based on a previously-used motor-intentional assessment.[20] Participants used the right hand to click a golf counter as many times as possible in 30 sec in both left and right space. Lateralized motor performance (LMP) was calculated as follows:

$$\text{LMP}=\left(\frac{\text{Number of Right Clicks}}{\text{Total Clicks}}\right)-\left(\frac{\text{Number of Left Clicks}}{\text{Total Clicks}}\right) \quad \text{Eq. 1}$$

Scores range from −1.0 to 1.0 (positive values indicate rightward bias and negative leftward bias).

Double Simultaneous Stimulation (DSS), *N*=47

Extinction to double simultaneous stimulation was tested in three modalities: vision, auditory, and tactile. For vision, the examiner stood centered at the participant's body midline with both hands raised. Across 15 trials, the examiner raised right, left or both index fingers. While looking at the examiner's nose, the participant indicated which fingers moved. For auditory DSS, the examiner sat behind the participant and snapped her fingers near the participant's ears. For tactile DSS, the examiner touched the participant's hands while the participant's eyes were closed. In each modality, five trials of each type (left, right, or bilateral) were performed and the number of correct bilateral detections was summed.

Fractionated Where and Aiming Measures, *N*=23

Participants sat at a computer monitor and bisected horizontal lines (subtending 23.6° visual angle) under both normal and reversed viewing conditions.[2] In both conditions, lines appeared one at a time, and participants clicked on the line's apparent center using a wireless mouse held in the right hand. Participants' vision of their hand was occluded by a wooden shelf. In the normal viewing condition the cursor moved in the same direction as the mouse. Under reversed conditions, visual feedback was left-right reversed such that rightward movements of the mouse resulted in leftward movements of the cursor and vice versa. We fractionated each participant's line bisection error into its "Where" and "Aiming" components using the following equations

$$\text{Normal Viewing Error}=\text{Where Component}+\text{Aiming Component} \quad \text{Eq. 2}$$

$$\text{Reversed Viewing Error}=\text{Aiming Component}-\text{Where Component} \quad \text{Eq. 3}$$

In the computerized line bisection task, rightward errors may be related to either perceptual-attentional "Where" unawareness or motor-intentional "Aiming" spatial bias, or some combination of both problems. Under normal viewing conditions, visually perceived right and left are aligned with right and left movement: Thus, the effects of "Where" and "Aiming" bias are additive (as in Eq. 2). However, when visual feedback of the cursor movement is right-left reversed (relative to the participant's actual movement in the workspace) "Where" perceptual-attentional feedback is reversed. As a result, participants demonstrate a *reversal* of the visual-feedback-dependent "Where" perceptual-attentional errors (hence the subtraction in Eq. 3). By solving for "Where" and "Aiming" spatial bias using Equations 2 and 3, we can separately quantify the perceptual-attentional "Where" and motor-intentional "Aiming" contributions to line bisection bias.

Analysis Plan

Our analysis goals were three-fold.

Goal 1—First, we wished to determine the reliability and factor structure of the BIT and CBS in an acute sample. We assessed the reliability of the BIT and CBS with coefficient alpha (α). Because the BIT items are measured on different scales, the items were standardized based on this sample's means and standard deviations prior to the reliability analysis. The factor structure of both scales was assessed with a PCA with Varimax (i.e., orthogonal) rotation using *PASW 18.0*. We retained as factors those components with eigenvalues greater than 1.0. When the analysis identified more than one factor, items were assigned to the factor on which they loaded most strongly, given that the factor loading was at least 0.40.[21] Because CBS items are ordinal rather than interval-level data, we conducted a Rasch analysis using *Winsteps 3.70.0.2* to confirm the dimensionality of the CBS as identified by the PCA. Rasch analysis yields a single interval-level measure from ordinal-level raw data, with difficulty scores for each item and ability scores for each participant. However, Rasch analysis assumes that the items form a unidimensional scale.[22] We tested this assumption within the Rasch analysis by performing a PCA of the residual variability unaccounted for by the Rasch measure. Any systematic factors in the residuals would suggest multidimensionality in the CBS scale. We did not apply Rasch analyses to the BIT: some BIT items are already interval measures, and therefore, not appropriate for use under the Rasch model.

Goal 2—We wished to determine whether the BIT and CBS assess the same underlying constructs. We performed a single PCA as described for Goal 1, but included items from both tests. We reverse-coded the CBS items so that higher scores indicated better function on both scales. The use of PCA to address Goal 2 was contingent on Rasch confirmation of the CBS PCA identified under Goal 1. Such confirmation would suggest that the PCA was appropriate for use with CBS items.

Goal 3—We wished to validate the BIT and CBS (or any identified subscales) by assessing their relation to laboratory and clinical assessments of perceptual-attentional and motor-intentional bias, as well as their relation to functional activities (Barthel Index). We performed partial correlations among the assessments controlling for age and days post-stroke. Further, we performed stepwise regression with BIT and CBS (or their subscales) as predictors and the Barthel Index as the outcome.

Hypotheses for Relations Among Neglect Measures

Visual and auditory DSS may be primarily perceptual-attentional tasks, and thus correlated with the Where spatial bias component. With its lateralized motor demands, the LMP was expected to correlate with Aiming bias. As tactile DSS may be associated with somesthetic-motor function, it may be related to both Where and Aiming bias components.[1,18,23] If we identified perceptual-attentional or motor-intentional components of the BIT or CBS, we expected these to be correlated with Where and Aiming spatial biases, respectively.

RESULTS

BIT

The scale had good reliability ($\alpha = 0.93$), which was further improved with the removal of the line bisection item ($\alpha = 0.94$). PCA yielded a single factor accounting for 75.3% of the variance (see Table 2). The line bisection item had a very poor communality (0.54) compared to other items on the scale (0.70 or greater).

CBS

The CBS demonstrated good reliability ($\alpha = 0.90$) among the 10 scale items. PCA identified two factors (see Table 3). The first factor accounted for 52.8% of the variance and consisted

of items assessing perceptual-attentional (PA) deficits. The second factor accounted for 14.4% of the variance and consisted of items potentially assessing embodied, motor-exploratory (ME) deficits.

Rasch analysis confirmed the multidimensionality of the CBS scale (see Table 4 for Rasch item statistics). While the Rasch measure accounted for 56.0% of the variance in the raw CBS item scores, PCA of the unexplained variance identified one contrast that accounted for an additional 10.9%. In this residual contrast, embodied, motor exploratory items had positive factor loadings of 0.40 or greater, while the remaining perceptual-attentional items loaded negatively (see right-most column of Table 4). This pattern of factor loadings confirms the existence of two distinct underlying constructs, potentially corresponding to perceptual-attentional and motor-exploratory components.

Combined PCA of CBS and 5-item BIT

This PCA revealed a 3-factor solution identical to the factor solutions arrived at through separate PCAs of the scales. The BIT emerged as the first factor, accounting for 47.6% of the variance. The CBS perceptual-attentional (CBS-PA) items emerged as the second factor, accounting for 14.4% of the variance and the CBS motor-exploratory (CBS-ME) items emerged as the third factor, accounting for 9.2% of the variance.

Associations Between Neglect Measures and Behavioral Tests

We created perceptual-attentional (CBS-PA) and motor-exploratory (CBS-ME) CBS sub-scores by taking the average of the six perceptual-attentional and four motor-exploratory items. As reported in Table 5, better performance on the BIT was associated with better detection on visual and tactile DSS, but the BIT was not related to other assessments.

We found support for our suggestion that CBS-PA items assess perceptual-attentional deficits. These scores predicted performance on perceptual-attentional behavioral tests: more severe CBS-PA was associated with poorer detection performance on visual and tactile DSS and with more rightward “Where” bias. The CBS-ME, however, was not related to “Aiming” or other motor-intentional bias assessments, although it was predictive of tactile DSS.

Predictors of Activities of Daily Living (Barthel Index)

We assessed the relation between the neglect tests and scores on the Barthel Index, controlling for age and number of days post-event. The CBS-ME was strongly related to Barthel Index scores as was the BIT, and to a lesser extent, the CBS-PA (see Table 5). To test how each uniquely predicted activities of daily living, we performed a stepwise multiple regression. Both the BIT (β=0.563, p<.001) and the CBS-ME (β=−0.347, p=.010), but not the CBS-PA (β=−0.041, p=.780), emerged as significant predictors of Barthel Index scores [R^2=0.41, F(2,46)=15.9, p<.001], with the BIT accounting for 31.7% of the variance. The CBS-ME uniquely accounted for an additional 9.2% of the variance.

DISCUSSION

In an acute sample of patients with left neglect, we demonstrated that the Catherine Bergego Scale, a functional neglect assessment, potentially includes two distinct underlying constructs: one perceptual-attentional (CBS-PA) and one associated with embodied, motor-exploratory bias (CBS-ME). This result is consistent with multiple spatial cognitive systems[1,14,16] potentially producing neglect symptoms. Previous research suggests that identifying the mechanisms of spatial dysfunction in acute patients may help identify

patients likely to experience chronic disability and need of increased caregiver assistance.[17] CBS-PA and -ME might also assist in triaging patients for targeted treatment programs.[18]

Previous studies identified a single CBS factor,[11,12] but this psychometric research did not include acute patients, in whom stroke care costs are greatest,[6] and for whom standardized assessment and intervention[5] is feasible in our current system of care. Others suggested review of individual CBS items as a method for stratifying patients.[24] However, in the absence of evidence regarding item-construct relationships, obtaining CBS-PA and CBS-ME sub-scores may be more valid. Further, we found that motor-exploratory deficits uniquely predicted functional disability. Because motor deficits may be associated with chronic persistence of neglect,[17] the CBS-ME may improve detection of individuals most likely to require increased assistance (e.g., long-term nursing care). Clinicians assessing visual-spatial attention and awareness, apparently measured by the BIT and CBS-PA items, may not be able to detect embodied, motor-exploratory spatial deficits, potentially salient to care, recovery, and response to rehabilitation treatments.

Perhaps surprisingly, scores on the CBS-ME were not related to other behavioral motor-intentional measures (lateralized motor performance, or rightward “Aiming” bias on computerized line bisection). However, there may be multiple spatial motor output systems.[16] “Aiming” line bisection bias, assessing directional hypokinesia, and LMP, assessing movement in left versus right hemispace, may both measure propensity to move in peripersonal action space. In contrast, the CBS-ME items may measure integrity of a whole-body, egocentric, reference frame that supports continuous computation and awareness of body center relative to the environment.[25,26] These spatial motor representations (peripersonal action-space and whole-body) are dissociable in healthy individuals,[26] and may dissociate in the performance of neglect patients. Consistent with this idea, better performance on the CBS-ME was associated with better performance on DSS-tactile: Recent research shows tactile representations to be partially dependent on whole-body, postural representations.[23]

Although our results challenge the unidimensionality of the CBS in acute neglect, we replicated previous work reporting the BIT to be unidimensional.[10,11] Although we do not know why line bisection item of the BIT had poor communality, patients bisect several lines on one page, perhaps inducing perseveration. Future work, in a larger sample of acute patients, should assess the appropriateness of the inclusion of the line bisection item on the BIT. Finally, simultaneous PCA of the BIT and CBS demonstrated that they assess distinct underlying constructs, suggesting the value of retention and use of both scales to accurately identify neglect sub-components. Although the BIT no doubt recruits both perceptual and spatial-cognitive motor systems, the CBS sub-scales may assess unique aspects of perceptual and motor dysfunction. Furthermore, the CBS sub-scales provide separate quantification of these aspects of neglect.

Study Limitations

The current study identifies a distinction motor-exploratory component to the CBS, and the work of others suggests that persistence to the chronic stage of neglect may be associated with spatial motor deficits.[17] The current study, however, did not directly demonstrate that the CBS-ME subscale is predictive of persistence to the chronic stage. Prospective research is needed to determine whether deficits of embodied motor exploration may be predictive of chronic disability. Furthermore, future research could further assess the validity of the motor-exploratory component of the CBS by including measures of whole-body spatial bias (e.g., postural measures). Lastly, it will be important to replicate the factor solution of CBS-PA and CBS-ME in large populations broadly representative of stroke survivors, as well as

to explore the effects of potential moderating variables on the stability of that factor structure.

Conclusion

We propose that a motor-exploratory subscale of the CBS may characterize spatial neglect after acute stroke, and optimally identify functional dependence. Future work needs to explore the extent to which this dimension of motor-exploratory bias may predict chronic neglect and disability, as well as its ability to predict treatment response. [18] Despite a paucity of research on acute-stage interventions, recent work suggests that they hold promise[5] and, given the high cost of acute-stage care,[6] reducing the acute-care burden is of vital importance.

Acknowledgments

Sources of Funding: This work was funded by the Kessler Foundation and the National Institute of Neurological Disorders and Stroke (K02 NS 047099-05, R01 NS 055808-02, PI: Barrett).

The authors thank Dr. Jeffery Zhang for statistical assistance and Naureen Zaidi for assistance with data collection and scoring.

References

1. Heilman, KM.; Watson, RT.; Valenstein, E. Neglect and related disorders. In: Valenstein, E., editor. Clinical neuropsychology. 4. New York, NY US: Oxford University Press; 2003. p. 296-346.
2. Barrett AM, Burkholder S. Monocular patching in subjects with right-hemisphere stroke affects perceptual-attentional bias. J Rehabil Res Dev. 2006; 43:337–346. [PubMed: 17041819]
3. Gillen R, Tennen H, McKee T. Unilateral spatial neglect: relation to rehabilitation outcomes in patients with right hemisphere stroke. Arch Phys Med Rehabil. 2005; 86:763–767. [PubMed: 15827929]
4. Hillis AE, Wityk RJ, Barker PB, Ulatowski JA, Jacobs MA. Change in perfusion in acute nondominant hemisphere stroke may be better estimated by tests of hemispatial neglect than by the National Institutes of Health Stroke Scale. Stroke. 2003; 34:2392–2396. [PubMed: 12958320]
5. Niemeier JP, Kreutzer JS, Marwitz JH, Gary KW, Ketchun JM. Efficacy of a brief acute neurobehavioural intervention following traumatic brain injury: A preliminary investigation. Brain Inj. 2011; 25:680–90. [PubMed: 21604926]
6. American Heart Association. Heart disease and stroke statistic—2011 update. Circulation. 2011; 123:e18–e209.10.1161/CIR.0b013e3182009701 [PubMed: 21160056]
7. Edwards DF, Hahn MG, Baum CM, Perlmutter MS, Sheedy C, Dromerick AW. Screening patients with stroke for rehabilitation needs: validation of the post-stroke rehabilitation guidelines. Neurorehabil Neural Repair. 2006; 20(1):42–48. [PubMed: 16467277]
8. Wilson, BA.; Cockburn, J.; Halligan, PW. Behavioural Inattention Test. Titchfield, Hants: Thames Valley Test Company; 1987.
9. Halligan PW, Cockburn J, Wilson BA. The behavioral assessment of visual neglect. Neuropsychol Rehabil. 1991; 1:5–32.
10. Halligan PW, Marshall JC, Wade DT. Visuospatial neglect: underlying factors and test sensitivity. Lancet. 1989; 2:908–911. [PubMed: 2571823]
11. Kutlay S, Kucukdeveci AA, Elhan AH, Tennant A. Validation of the Behavioural Inattention Test (BIT) in patients with acquired brain injury in Turkey. Neuropsychol Rehabil. 2009; 19:461–475. [PubMed: 19085520]
12. Azouvi P, Marchal F, Samuel C, Morin L, Renard C, Louis-Dreyfus A, Jokic C, Wiart L, Pradat-Diehl P, Deloche G, Bergego C. Functional consequences and awareness of unilateral neglect: Study of an evaluation scale. Neuropsychol Rehabil. 1996; 6:133–150.

13. Azouvi P, Olivier S, de Montety G, Samuel C, Louis-Dreyfus A, Tesio L. Behavioral assessment of unilateral neglect: study of the psychometric properties of the Catherine Bergego Scale. Arch Phys Med Rehabil. 2003; 84:51–57. [PubMed: 12589620]
14. Na DL, Adair JC, Williamson DJ, Schwartz RL, Haws B, Heilman KM. Dissociation of sensory-attentional from motor-intentional neglect. J Neurol Neurosurg Psychiatry. 1998; 64:331–338. [PubMed: 9527144]
15. Mesulam, M. Attentional networks, confusional states, and neglect syndromes. In: Mesulam, M., editor. Principles of behavioral and cognitive neurology. 2. New York, NY US: Oxford University Press; 2000. p. 174-256.
16. Heilman KM. Intentional neglect. Front Biosci. 2004; 9:694–705. [PubMed: 14766401]
17. Farne A, Buxbaum LJ, Ferraro M, Frassinetti F, Whyte J, Veramonti T, Angeli V, Coslett HB, Ladavas E. Patterns of spontaneous recovery of neglect and associated disorders in acute right brain-damaged patients. J Neurol Neurosurg Psychiatry. 2004; 75:1401–1410. [PubMed: 15377685]
18. Eskes, GA.; Barrett, AM. Neuropsychological rehabilitation. In: Lazar, RM., editor. Neurovascular neuropsychology. New York, NY US: Springer Science + Business Media; 2009. p. 281-305.
19. Raczkowski D, Kalat JW, Nebes R. Reliability and validity of some handedness questionnaire items. Neuropsychologia. 1973; 12:43–47. [PubMed: 4821188]
20. Hillis AE, Chang S, Heidler-Gary J, Newhart M, Kleinman JT, Davis C, Barker PB, Aldrich E, Ken L. Neural correlates of modality-specific spatial extinction. J Cogn Neurosci. 2006; 18:1889–1898. [PubMed: 17069479]
21. Floyd FJ, Widaman KF. Factor analysis in the development and refinement of clinical assessment instruments. Psychol Assess. 1995:286–299.10.1037//1040-3590.7.3.286
22. Bond, TG.; Fox, CM. Applying the Rasch Model: Fundamental Measurement in the Human Sciences. 2. Mahwah, NJ: Lawrence Erlbaum; 2007.
23. Medina J, Coslett HB. From maps to form to space: touch and the body schema. Neuropsychologia. 2010; 48:645–654. [PubMed: 19699214]
24. Plummer P, Morris ME, Dunai J. Assessment of unilateral neglect. Phys Ther. 2003; 83:732–740. [PubMed: 12882614]
25. Beschin N, Cubelli R, Sala SD, Spinazzola L. Left of what? The role of egocentric coordinates in neglect. J Neurol Neurosurg Psychiatry. 1997; 63:483–489. [PubMed: 9343128]
26. Witt JK, Ashe J, Willingham DT. An egocentric frame of reference in implicit motor sequence learning. Psychological Research/Psychologische Forschung. 2008; 72:542–552.

Table 1

Participant characteristics.

Measure	Mean	SD	Range
Days Post-Stroke	22.3	10.9	9–61
Age (years)	66.9	15.9	28–90
Education (years)	13.2	3.2	6–20
6-item BIT	66.2	44.8	11–137
5-item BIT	63.6	43.2	9–131
CBS	19.3	6.7	2–30
CBS-PA	1.7	0.8	0.17–3.0
CBS-ME	2.3	0.7	0–3.0
Barthel	26.1	24.1	0–95
DSS-Total	5.9	4.8	0–15
DSS-Visual	1.6	2.0	0–5
DSS-Auditory	2.30	2.2	0–5
DSS-Tactile	2.0	2.1	0–5
LMP	0.01	0.11	−0.23 to 0.28
Where Bias	5.8	24.1	−35.35 to 78.16
Aiming Bias	2.5	15.1	−14.67 to 56.66

Table 2

Principal components analysis of BIT-Conventional.

Item	Factor Loading	Communality
Letter Cancellation	0.93	0.87
Star Cancellation	0.93	0.86
Line Crossing	0.91	0.82
Copying	0.85	0.73
Representational Drawing	0.84	0.70
Line Bisection	0.73	0.54

Table 3

Principal components analysis of the CBS.

Factor 1: Perceptual-Attentional Items	**Factor 1 Loading**	**Factor 2 Loading**
Finding belongings	0.84	0.12
Eating food	0.77	0.41
Cleaning mouth after eating	0.77	0.12
Attending to noise or people addressing from left	0.75	0.30
Spontaneously looking	0.69	0.08
Grooming face	0.65	0.39
Factor 2: Motor-Exploratory Items		
Collides with people or objects	0.22	0.85
Adjusting sleeve/slipper/pant leg	0.20	0.84
Forgets parts of body	0.07	0.79
Finding way on left when traveling in familiar places	0.40	0.76

Table 4

Rasch statistics and PCA of standardized residuals.

Item	Difficulty (logits)	Infit Mnsq	Outfit Mnsq	Pt. Bis Correlation	PCA of Residuals: Loading on 1st Contrast
Grooming face	1.56	0.95	0.91	0.79	−0.19
Cleaning mouth	1.19	1.11	1.05	0.71	−0.55
Attending to noise or people	0.66	0.80	0.78	0.78	−0.40
Eating food	0.75	0.56	0.56	0.80	−0.51
Finding belongings	−0.34	1.25	1.29	0.61	−0.52
Spontaneously looking	−0.43	1.19	1.08	0.63	−0.19
Forgets to use parts of body	−0.85	1.36	1.30	0.57	0.45
Finding way on left	−0.76	0.84	0.68	0.67	0.59
Collides with people or objects	−0.86	1.06	1.08	0.59	0.78
Adjusting sleeve/slipper/pants	−0.93	0.86	0.86	0.66	0.51

Note: *Mnsq* indicates means square. *Pt. Bis* indicates the point biserial correlation of the item with the Rasch measure.

Table 5

Partial correlations among measures, controlling for age and days post-stroke.

	BIT	CBS-PA	CBS-ME
DSS-Visual	0.46‡	−0.44‡	−0.15
DSS-Auditory	−0.05	−0.13	−0.07
DSS-Tactile	0.35*	−0.49‡	−0.40‡
LMP	0.11	−0.24	−0.16
Where	−0.09	0.45*	0.23
Aiming	0.08	−0.11	−0.11
Barthel	0.40†	−0.33*	−0.43‡

Note: Higher scores on the BIT-5, DSS, and Barthel indicate better performance. For all others, lower scores indicate either better performance or less rightward bias.

*indicates $p < 0.05$;

†indicates $p < 0.01$;

‡indicates $p < 0.001$