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Line bisection test

The Line Bisection Test is a test is a quick measure to detect the presence of unilateral spatial neglect (USN). To complete the test, one must place a mark with a pencil through the center of a series of horizontal lines. Usually, a displacement of the bisection mark towards the side of the brain lesion is interpreted as a symptom of neglect. In-Depth Review Purpose of the measure The Line Bisection Test is a test is a quick measure to detect the presence of unilateral spatial neglect (USN). To complete the test, one must place a mark with a pencil through the center of a series of horizontal lines. Usually, a displacement of the bisection mark towards the side of the brain lesion is interpreted as a symptom of neglect. Available versions There are many versions of the Line Bisection Test, and the procedures are rarely standardized, with the exception of when the Line Bisection Test is used as an item within a standardized test battery (Plummer, Morris, & Dunai, 2003). The relationship between abnormal line bisection and visual neglect has been observed for over a century (e.g. Axenfeld, 1894; Liepmann & Kalmus, 1900). In 1980, Schenkenberg, Bradford, and Ajax formally evaluated this method of detecting the presence of visual neglect in patients with lesions of the non-dominant hemisphere, and are thought to be the first to statistically evaluate this method. Features of the measure Items: Patients are asked to place a mark with a pencil (with their preferred or unaffected hand) through the center of a series of 18 horizontal lines on an 11x 8.5-inch page. Scoring: The test is scored by measuring the deviation of the bisection from the true center of the line. A deviation of more than 6 mm from the midpoint indicates USN. Omission of two or more lines on one half of the page indicates USN. Time: The test takes less than 5 minutes to complete. Training: None typically reported. Subscales: None. Equipment: 11x 8.5-inch page of paper with 18 horizontal lines Pencil Alternative form of the Line Bisection Test The Line Bisection Test can be presented in various forms. Some studies use 18 horizontal lines, while others have used a single line (Parton, Malhotra & Husain, 2004), or a series of 10 lines (Ferber & Karnath, 2001). The Line Bisection Test is also offered as part of some standardized test batteries such as within the Behavioural Inattention Test (Wilson, Cockburn, Halligan, 1987; Schubert & Spatt, 2001). Client suitability Can be used with: Patients with strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain.. Patients must be able to hold a pencil in order to complete the task (the presence of apraxia may impair this ability). Should not be used with: The Line Bisection Test should be used with caution in the clinical diagnosis of spatial neglect: Ferber and Karnath (2001) found that deviation in line bisection was not apparent in 40% of the patients in their sample that had severe neglect. In comparison, each of the four cancellation tests administered in this study (Line Crossing, Letter Cancellation, Star Cancellation Test and Bells Test) missed 6% of the subjects and may be preferred over the Line Bisection Test for diagnosing USN. Performance on the Line Bisection Test may be influenced by or may be indicative of other syndromes besides spatial neglect, such as hemianopia (damage of optic pathways that result in loss of vision in half of the visual field) (Ferber & Karnath, 2001). Consequently, the Line Bisection Test is not a highly specific measure of USN. In what languages is the measure available? Not applicable. Summary What does the tool measure? Unilateral Spatial Neglect (USN) in the extrapersonal space What types of clients can the tool be used for? Patients with strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain.. Is this a screeningTesting for disease in people without symptoms. or assessment tool? ScreeningTesting for disease in people without symptoms.. Time to administer Less than 5 minutes. Versions There are many versions of the Line Bisection Test, and the procedures are rarely standardized, with the exception of when the Line Bisection Test is used as an item within a standardized test battery such as in the Behavioural Inattention Test. Other Languages Not applicable. Measurement Properties ReliabilityReliability can be defined in a variety of ways. It is generally understood to be the extent to which a measure is stable or consistent and produces similar results when administered repeatedly. A more technical definition of reliability is that it is the proportion of "true" variation in scores derived from a particular measure. The total variation in any given score may be thought of as consisting of true variation (the variation of interest) and error variation (which includes random error as well as systematic error). True variation is that variation which actually reflects differences in the construct under study, e.g., the actual severity of neurological impairment. Random error refers to "noise" in the scores due to chance factors, e.g., a loud noise distracts a patient thus affecting his performance, which, in turn, affects the score. Systematic error refers to bias that influences scores in a specific direction in a fairly consistent way, e.g., one neurologist in a group tends to rate all patients as being more disabled than do other neurologists in the group. There are many variations on the measurement of reliability including alternate-forms, internal consistency , inter-rater agreement , intra-rater agreement , and test-retest . Test-retest: Four studies have examined the test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society). of the Line Bisection Test. Three studies reported excellent test-retest and one study reported adequate test-retest. ValidityThe degree to which an assessment measures what it is supposed to measure. Criterion: One study reported that when the Line Bisection Test was compared to other cancellation tests, the sensitivitySensitivity refers to the probability that a diagnostic technique will detect a particular disease or condition when it does indeed exist in a patient (National Multiple Sclerosis Society). See also "Specificity." of the Line Bisection Test. Construct: Convergent: Excellent correlations with Albert's Test and the Baking Tray Task. Adequate correlations with the Star Cancellation Test and with mean CT-scan damage. Poor correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. with the Clock Drawing Test. Does the tool detect change in patients? Not applicable. Acceptability The Line Bisection Test should be used as a screeningTesting for disease in people without symptoms. tool rather than for clinical diagnosis of USN. Performance on the Line Bisection Test may be influenced by or may be indicative of other syndromes besides spatial neglect, such as hemianopia. Apraxia must be ruled out as this may affect the validityThe degree to which an assessment measures what it is supposed to measure. of test results. This test cannot be completed by proxy. Patients must be able to hold a pencil to complete. Feasibility The Line Bisection Test takes only 5 minutes to complete and is simple to score. Only simple equipment is required (a pencil and paper with 18 horizontal lines). How to obtain the tool? The Line Bisection Test can be purchased as part of the Behavioural Inattention Test from Pearson Assessment by clicking on the following link: Detail.htm?CS_Category=&CS_Catalog=TPC-CACatalog&CS_ProductID=7491129972 Psychometric Properties Overview For the purposes of this review, we conducted a literature search to identify all relevant publications on the psychometric properties of the Line Bisection Test. The test has been evaluated in many studies for its criterion validityExamines the extent to which a measure provides results that are consistent with a gold standard . It is typically divided into concurrent validity and predictive validity ., resulting in evidence of its strong psychometric properties in comparison to other paper-and-pencil tests (Menon & Korner-Bitensky, 2004). Reliability Test-retest: Schenkenberg et al. (1980) examined the test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society). of the Line Bisection Test in patients with right-hemisphere lesions, diffuse lesions, left-hemisphere lesions, and hospital controls, and found that it had excellent test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society), ranging from r = 0.84 to r = 0.93. Similarly, Chen-Sea and Henderson (1994) reported an excellent test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society). of r = 0.93 for the Line Bisection Test. Kinsella, Packer, Ng, Olver, and Stark (1995) found adequate test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society). for the Line Bisection Test (Pearson r = 0.64). Bailey, Riddoch and Crome (2004) examined the test-retest reliabilityA way of estimating the reliability of a scale in which individuals are administered the same scale on two different occasions and then the two scores are assessed for consistency. This method of evaluating reliability is appropriate only if the phenomenon that the scale measures is known to be stable over the interval between assessments. If the phenomenon being measured fluctuates substantially over time, then the test-retest paradigm may significantly underestimate reliability. In using test-retest reliability, the investigator needs to take into account the possibility of practice effects, which can artificially inflate the estimate of reliability (National Multiple Sclerosis Society). of the Line Bisection Test in elderly patients with a history of strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain. (85 patients with neglect and 83 patients without neglect). Patients repeated the test within the hour. The intraclass correlation coefficient (ICC)Intraclass correlation (ICC) is used to measure inter-rater reliability for two or more raters. It may also be used to assess test-retest reliability. ICC may be conceptualized as the ratio of between-groups variance to total variance. was excellent for patients with neglect (ICC = 0.97). Validity Criterion: Bailey, Riddoch, and Crome (2000) found that when the Line Bisection Test was compared to other cancellation tests, the sensitivitySensitivity refers to the probability that a diagnostic technique will detect a particular disease or condition when it does indeed exist in a patient (National Multiple Sclerosis Society). See also "Specificity." of the test for detecting visuo-spatial neglect in elderly patients with strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain.. In the absence of a gold standard , construct validation occurs, where theories about the attribute of interest are formed. Construct: Marsh and Kersel (1993) examined the construct validityReflects the ability of an instrument to measure an abstract concept, or construct. For some attributes, no gold standard exists. In the absence of a gold standard , construct validation occurs, where theories about the attribute of interest are formed, and then the extent to which the measure under investigation provides results that are consistent with these theories are assessed. of the Line Bisection Test by correlating the test with the Star Cancellation Test using Pearson's correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. in a sample of 27 rehabilitation patients with a history of strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain.. The two measures were found to have an adequate negative correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. (r = -0.40). The correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. lobe, and occipital lobe. All correlations were found to be adequate (r = -0.44, -0.59,-0.37, and -0.42, respectively). Friedman (1990) examined whether the Line Bisection Test with functional outcome in 82 elderly patients within 14 days of acute-lacunar strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain.. At discharge assessment, patients with impaired line bisection had poorer functional outcome than those with normal line bisection as measured by Barthel Index scores, walking speed and discharge destination. When subjects with impaired line bisection were divided into two groups according to line bisection score, the severely impaired had worse functional outcome than the mildly impaired. Convergent: Agrell, Dehlin, and Dahlgren (1997) compared the performance of 57 elderly patients with strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain. on 5 different tests for visuo-spatial neglect (Star Cancellation Test, Line Crossing-Albert's Test, Line Bisection, Clock Drawing Test and Copy A Cross). The Line Bisection Test had an excellent correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. with Line Crossing-Albert's Test (r = 0.85) and correlated adequately with the Star Cancellation Test (r = -0.33). Bailey, Riddoch, and Crome (2000) administered the Line Bisection Test and the Baking Tray Task to 107 patients with right hemisphere strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain., no significant correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. (r = -0.66). This correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. indicates the presence of USN, whereas a high score on the Baking Tray Task indicates normal performance. Binder, Marshall, Lazer, Benjamin, and Mohr (1992) compared the performance on line bisection with that at Letter Cancellation in a group of 34 patients with right-sided brain damage. They found no significant correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. (r = 0.39) between the scores in the two tests. Similarly, Schubert and Spatt (2001) found that in 20 patients with right hemisphere strokeAlso called a "brain attack" and happens when brain cells die because of inadequate blood flow. 20% of cases are a hemorrhage in the brain caused by a rupture or leakage from a blood vessel. 80% of cases are also know as a "schemic stroke", or the formation of a blood clot in a vessel supplying blood to the brain., no significant correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. between the Line Bisection Test and the Star Cancellation Test were found (r = 0.48). Furthermore, five patients with impaired performance on one of the tests were within the normal range on the other one. Ishiai, Sugishita, Ichikawa, Gono, and Watabiki (1993) examined the construct validityReflects the ability of an instrument to measure an abstract concept, or construct. For some attributes, no gold standard exists. In the absence of a gold standard , construct validation occurs, where theories about the attribute of interest are formed, and then the extent to which the measure under investigation provides results that are consistent with these theories are assessed of the Clock Drawing Test and found that it had a poor correlationThe extent to which two or more variables are associated with one another. A correlation can be positive (as one variable increases, the other also increases - for example height and weight typically represent a positive correlation) or negative (as one variable increases, the other decreases - for example as the cost of gasoline goes higher, the number of miles driven decreases. There are a wide variety of methods for measuring correlation including: intraclass correlation coefficients (ICC), the Pearson product-moment correlation coefficient, and the Spearman rank-order correlation. with the Line Bisection Test (r = 0.05). Known groups: Schenkenberg et al. (1980) reported that Line Bisection Test performance can discriminate between patients with right-hemisphere lesions and patients with left-hemisphere lesions, and hospital controls. Responsiveness No evidence. References Agrell, B. M., Dehlin, O. I., Dahlgren, C. J. (1997). Neglect in elderly stroke patients: a comparison of five tests. Psychiatry Clin Neurosci, 51(5), 295-300. Axenfeld, D. (1894). Eine einfache Methode Hemianopsie zu constatiren. Neurol Centralbl, 437-438. Bailey, M. J., Riddoch, M. J., Crome, P. (2000). Evaluation of a test battery for hemineglect in elderly stroke patients for use by therapists in clinical practice. NeuroRehabilitation, 14, 139-150. Bailey, M. J., Riddoch, M. J., Crome, P. (2004). Test-retest stability of three tests for unilateral visual neglect. In: Marshall JC & Robertson IH, editors. Spatial neglect - A clinical review. Psychology Press. NeuroRehabilitation, 14(4), 403-419. Barton, J. J. S., Black, S. E. (1998). Line bisection in hemianopia. 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Line bisection and unilateral visual neglect in patients with neurological impairment. Neurology. 30, 509-517. Schubert, F., Spatt, J. (2001). Double dissociations between neglect tests: Possible relation to lesion site. Eur Neurol, 45, 160-164. Wilson, B. A., Cockburn, J., Halligan, P. W. (1987). Behavioural Inattention Test. Titchfield, Hants, England: Thames Valley Test Company Ltd. See the measure How to obtain the Line Bisection Test? Click here to obtain a copy of the Line Bisection Test The Line Bisection Test can be purchased as part of the Behavioural Inattention Test from Pearson Assessment by clicking on the following link: Pearson Assessment Table of contents As a library, NLM provides access to scientific literature. Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health. Learn more: PMC Disclaimer | PMC Copyright Notice . 2011 Jul 28;6(7):e23017. doi: 10.1371/journal.pone.0023017 Damage to the parietal lobe can induce a condition known as spatial neglect, characterized by a lack of awareness of the personal and/or extrapersonal space opposite the damaged brain region. Spatial neglect is commonly associated clinically using either the line bisection or the target cancellation task. However, it is unclear whether poor performance on each of these two tasks is associated with the same or different lesion locations. To date, methodological limitations and differences have prevented a definitive link between task performance and lesion location to be made. Here we report findings from a voxel-based lesion symptom mapping (VLSM) analysis of an unbiased selection of 44 patients with a recent unilateral stroke. Patients performed both the line bisection and the target cancellation task. For each of the two tasks a continuous score was incorporated into the VLSM analysis. Both tasks correlated highly with each other (r = .76) and VLSM analyses indicated that the angular gyrus was the critical lesion site for both tasks. The results suggest that both tasks probe the same underlying cortical deficits and although the cancellation task was more sensitive than the line bisection task, both can be used in a clinical setting to test for spatial neglect. Visual neglect is defined as the inability to detect, attend or respond to stimuli in spatial locations contralateral to the side of cerebral damage [1]. The two tasks most commonly used to test for neglect in a clinical setting are the cancellation task [2] and the line bisection task [3]. It is currently unclear, however, whether the same underlying cortical processes are activated with these two tests for neglect. The line bisection and target cancellation task have been found to load on different factors in some studies [4] but others [5] found that different neglect tasks (including the line bisection and target cancellation task) all loaded high on the same factor. Spatial neglect is defined as the inability to detect and respond to stimuli in spatial locations contralateral to the side of cerebral damage [1]. The results suggest that both tasks probe the same underlying cortical deficits and although the cancellation task was more sensitive than the line bisection task, both can be used in a clinical setting to test for spatial neglect. Visual neglect is defined as the inability to detect, attend or respond to stimuli in spatial locations contralateral to the side of cerebral damage [1]. performance on both tasks seems to be correlated [7]. Recently there has been some debate on the location of the critical lesion site for neglect. Some authors argue for the angular gyrus [8] while others [9], [10], [11] attribute this role to the superior temporal gyrus. One explanation for this discrepancy has been that different neglect tasks in these studies [12], [13]. Rorden et al. (2006) found that patients who have more posterior lesions (temporo-occipital junction) than patients who have anterior lesions. These latter patients have lesions in the right inferior parietal lobule were more associated with problems on the line bisection task, and lesions in the right dorsolateral prefrontal cortex were more associated with problems on the target cancellation task. Others only found a behavioral, but not an anatomical, separation between the two tasks [14]. If both tasks are uncorrelated, and test for different underlying brain lesions, this would have important implications for the use of these tasks in the everyday clinical setting. Therefore, the present study sought to resolve the controversy surrounding task performance and lesion location using an unbiased sample of 44 stroke patients. Rather than pre-categorizing the patients into dichotomous groups with an all-or-none approach to behavior, as in traditional subtraction and overlap approaches [12], [8], [9], a continuous measure was used in this VLSM analysis [15], [16]. This analysis method is the most appropriate for addressing the issue of task performance and lesion location as it utilizes continuous lesion and behavioral data. All participants gave written informed consent in accordance with the Declaration of Helsinki. The ethical commission at the University Hospital Leuven approved the experimental protocol. A consecutive series of 44 ischemic hemispheric stroke patients (See Table 1 for details) who had suffered a non-lacunar unifocal ischemic hemispheric stroke, confirmed on clinical Fluid Attenuation Inversion Recovery (FLAIR) or Diffusion-Weighted Imaging (DWI) magnetic resonance imaging (MRI) participated in the study. Participants were excluded if they were aged over 85 years, had a pre-existing periventricular or subcortical white matter lesions or a pre-existing stroke on MRI, had insufficient balance to sit independently, and general inability to understand and carry out the task. Although spatial neglect is more frequent after a right hemisphere lesion, it is not uncommon for patients to experience neglect also after a left hemisphere lesion [17]. Therefore both left- and right-sided patients were included in this study. The anatomical distribution of the ischemic lesions is shown in Figure 1. Visual fields were intact except in case 10 (left hemianopia), 14 (right lower quadrantanopia), 15 (left upper quadrantanopia) and 32 (left lower quadrantanopia). case age lesion side lesion size cm 3 days since stroke onset Bells omissions L_M_R Line Bisection % case Age

case	age	lesion side	lesion size cm	3 days since stroke onset	Bells omissions L	M	R	Line Bisection %	case	Age	lesion side	lesion size cm	3 days since stroke onset	Bells omissions L	M	R	Line Bisection %
1	43	R	26.9	4	0	0	1	+5.8	23	37	L	11.2	21	0	0	+0.4
2	82	R	20.2	51	0	0	+3.7	24	76	L	4.0	51	1	2	+4.6
3	44	R	28.7	27	2	2	4	+1.8	25	79	R	40.8	14	2	1	−3.8
4	69	L	1.9	80	4.1	7	2	2	+1.9	26	73	L	16.4	4	0	0
5	88	R	84.1	7	2	2	4	+1.8	27	84	R	302.7	4	1	0	−5.2
6	79	R	17.3	0.6	14	0	+20.5	28	33	L	16.4	4.0	0	0	−0.3
7	72	L	46.8	3.2	4	0	−1.7	29	42	R	43.4	6.4	3	1	+18.7
8	65	R	1.95	1	126	1	1	2	+0.5	30	54	R	30.2	5.2	2	0
9	80	R	16.7	17.0	5.2	0	+5.8	31	77	L	173.0	6.1	4.8	3	−3.3
10	32	L	34	7.4	4	14	147.2	1.0	−5.9	37	64	R	107.0	196	3	0
11	63	L	1.8	5	7.0	1	1	+5.2	17	64	R	216.0	5	15	4.2
12	74	L	13.9	5.0	1	0	+3.8	36	55	R	2.6	140	1.0	0	−3.6
13	51	R	14.3	147.2	1.0	−5.9	37	64	R	107.0	196	3	0	1
14	69	R	161.0	91	0.0	0	+5.0	21	84	L	5.2	6	0.0	0
15	64	L	4.0	35	5L	64.4	63.0	0	0	+0.1	19	75	R	4.9	61	8.0
16	124	6	126	3_1_0	+6.3												

The color code indicates in how many individuals a given voxel was lesioned (ranging from 1 to 13). Participants completed two standard neuropsychological test of neglect. The first task was the bells target cancellation task [2]. This task consists of seven columns presented on an A4 sheet of paper, each containing five targets (bells) and 40 distractors. Three of the seven columns are on the left side of the A4 sheet (15 targets), one is in the middle and three are on the right (15 targets). Participants were asked to cross out all the bells. The number of omissions on the contralesional side minus the number of omissions on the ipsilesional side was calculated, and used as a score in the VLSM analysis. Participants were classified as having spatial neglect if they had three additional omissions on the ipsilesional side compared to the contralesional side [2]. The second test of neglect was the line bisection task [3]. Participants were required to bisect a number of lines (20) in half with varying lengths (100, 120, 140, 150 160, 180 and 200 mm) by placing a small pencil mark trough each line as close to the center as possible. The mean percentage deviation from the middle to the ipsilesional side over all the lines was used as a score in the VLSM analysis. Ipsilesional deviation above 9.5 percent was taken as an indicator of spatial neglect. This number corresponds to a value above the 99 percent confidence interval in a control group [3]. Each of the 44 patients had an MRI scan (see [18], [19] for a similar procedure in the same patients) with a 3 T Philips Intera system (Best, Netherlands) equipped with a head volume coil that provided T1 images (TR=1975 ms, TE=30 ms, in-plane resolution 1mm) as well as Fluid Attenuation Inversion Recovery (FLAIR) 3D images (TR=10,741 ms, TE=150 ms). Using SPM2 (, Welcome Trust Centre for Neuroimaging, London, UK) the T1 and FLAIR images were co-registered. The T1 scan was normalized to the Montreal Neurological Institute (MNI) T1 template in Talairach space [20], [21]. The spatial normalization involved both linear (12 affine transformations) and nonlinear (7×9×7 basis functions, 16 reiterations) transformations [22]. High regularization was used to constrain the non-linear part of the algorithm and penalize unlikely deformations associated with the presence of lesions [22], [23]. The same normalization matrix was applied to the FLAIR images. The match between each patient's normalized brain and the brain template was carefully evaluated through visual inspection and use of a cross-hair yoked between the template image and the normalized image. After verification of the normalization, lesions were semi-automatically delineated using MRIcro version 1.37 (and intensity thresholds were set manually [16]. The lesion volumes were subsequently imported into the MRIcron lesion-symptom mapping software (. A voxel was included in the analysis only if it was lesioned in at least 4 of the subjects. Each of the 2 parameters were entered separately into a VLSM analysis [16] that examined which of the voxels, when lesioned, were associated with significantly worse scores compared to patients in whom these voxels were intact (Brunner and Munzel t test [24]). The significance threshold was set at P