Author Manuscript
Author Manuscript
Author Manuscript
Author Manuscript

HHS Public Access
Author manuscript
Neuropsychology. Author manuscript; available in PMC 2019 October 01.

Published in final edited form as:
Neuropsychology. 2018 October ; 32(7): 835–842. doi:10.1037/neu0000469.

Conventional and Functional Assessment of Spatial Neglect: Clinical Practice Suggestions

Marco Pitteri,
University of Verona

Peii Chen,
Kessler Foundation, West Orange, New Jersey, and Rutgers New Jersey Medical School

Laura Passarini,
IRCCS San Camillo Hospital Foundation, Venice, Italy

Silvia Albanese,
IRCCS San Camillo Hospital Foundation, Venice, Italy

Francesca Meneghello, and
IRCCS San Camillo Hospital Foundation, Venice, Italy

A. M. Barrett
Kessler Foundation, West Orange, New Jersey; Rutgers New Jersey Medical School; and Kessler Institute for Rehabilitation, West Orange, New Jersey

Abstract

Objective: Spatial neglect (SN) constitutes a substantial barrier to functional recovery after acquired brain injury. However, because of its multimodal nature, no single test can capture all the signs of SN. To provide a clinically feasible solution, we used conventional neuropsychological tests as well as the Catherine Bergego Scale (CBS) via the Kessler Foundation Neglect Assessment Process (KF-NAP). The goal was to add evidence that a global approach should detect better even subtle signs of SN.

Method: Fourteen individuals with lesions located in the right cerebral hemisphere participated in the study. Participants were assessed with a comprehensive battery of neuropsychological tests, comprising a set of visuospatial tests to evaluate several spatial domains. In addition, patients underwent functional assessment with the Barthel Index, the Functional Independence Measure (FIM), and the CBS via KF-NAP.

Correspondence concerning this article should be addressed to Marco Pitteri, Neurology Section, Department of Neurosciences, Biomedicine and Movement Sciences, University of Verona, Piazzale Ludovico Antonio Scuro, 10, 37134 Verona, Italy., marco.pitteri@univr.it.

Marco Pitteri, Neurology Section, Department of Neurosciences, Biomedicine and Movement Sciences, University of Verona. Peii Chen, Kessler Foundation, West Orange, New Jersey, and Department of Physical Medicine and Rehabilitation, Rutgers New Jersey Medical School. Laura Passarini, Silvia Albanese, and Francesca Meneghello, Laboratory of Neuropsychology, IRCCS San Camillo Hospital Foundation, Venice, Italy. A. M. Barrett, Kessler Foundation; Department of Physical Medicine and Rehabilitation, Rutgers New Jersey Medical School; and Kessler Institute for Rehabilitation, West Orange, New Jersey.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Results: The CBS via KF-NAP was associated with the visuospatial paper-based tests ($p = .004$) as well as the Motor FIM ($p = .003$), and was more sensitive than the Behavioral Inattention Test-Conventional in detecting SN ($p = .014$).

Conclusions: We showed that the CBS via KF-NAP was able: (a) to detect functional impairment, especially motor, related to SN; (b) to selectively measures spatial rather than nonspatial dysfunctions; and (c) to be highly sensitive in detecting SN signs especially in those patients with mild severity, covering several aspects of SN manifestations. The patient's SN diagnosis based on the CBS via KF-NAP is clinically important and directly relevant to care planning and goal setting.

Keywords

spatial neglect; Catherine Bergego Scale (CBS); Kessler Foundation Neglect Assessment Process (KF-NAP); Barthel Index; functional independence measure (FIM)

Spatial neglect (SN) is a multimodal syndrome, in which patients fail to respond, orient to, or acknowledge stimuli in the contralesional side of space (Heilman, Watson, & Valenstein, 2003), causing disability (Barrett & Burkholder, 2006). Many subtypes or forms of SN have been described, each of which can be expressed in three spatial dimensions: the dimension of processing stage (perceptual-attentional, representational, and motor-intentional), the dimension of reference frame (egocentric, allocentric), and the dimension of spatial sector (personal, peripersonal, and extrapersonal). A sign of SN can be described with all three dimensions. For example, shaving one side of one's own face without attending the other side can be a result of motor-intentional, egocentric, personal neglect.

SN is more frequent and severe after brain injuries leaving damages in the right hemisphere than left hemisphere (Beis et al., 2004; Chen, Chen, Hreha, Goedert, & Barrett, 2015; Kleinman et al., 2007), although SN associated with left-hemisphere damage is still underinvestigated (Blini et al., 2016; Hreha et al., 2016). Spontaneous recovery occurs in the majority of patients, but SN might remain severe in many patients and may persist in the chronic phase (Katz, Hartman-Maeir, Ring, & Soroker, 1999; Nijboer, Kollen, & Kwakkel, 2013) constituting a substantial barrier to functional recovery (Buxbaum et al., 2004; Jehkonen et al., 2001).

SN is typically evaluated with clinical assessment and conventional neuropsychological tests. Currently there is no gold standard or universally accepted method for diagnosing SN. The presence and severity of SN is modulated by several factors (e.g., time post injury onset, arousal state), and different assessment methods are sensitive to different SN signs and symptoms (Azouvi et al., 2002; Riestra & Barrett, 2013). For instance, in the acute phase, SN can be easily detected with clinical observation and neuropsychological tests. With increasing time from injury onset, the majority of patients may do well in neuropsychological tests, but many patients still have difficulty in daily life activities that require adequate control of spatial attention and awareness. It is possible that the sensitivity of neuropsychological tests decreases over the course of recovery because patients learned to compensate successfully for their deficits during conventional testing, or because the abilities required to perform well in neuropsychological tests might not correspond

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

sufficiently to tasks and activities in patients' everyday environment (Bonato, Priftis, Marenzi, Umiltà, & Zorzi, 2010, 2012).

To reveal SN deficits that are not always detectable in conventional paper-based tests, some authors proposed to use computer-based testing (Bonato & Deouell, 2013; Schendel & Robertson, 2002). No study available so far, however, indicates that computerized testing is better than paper-based tests in predicting SN-related disability. Despite of many advantages for clinical implementation (e.g., reduced time in scoring), the computerized approach does not seem to replace the conventional approach. The majority of clinicians still prefer to administer paper-based neuropsychological tests rather than using an electronic device such as a computer or tablet. One of the main reasons is probably that conventional tests require relatively short time to administer and that paper-based tasks are often easily understood by patients also in the acute phase; moreover, clinicians are usually not well equipped with digital resources at the bed side, so low-tech methods with paper-based tasks are just simpler, easier, and cheaper.

Given the complexity and variety of SN signs and symptoms, using a set of different tests is crucial to improve sensitivity in detecting SN (Azouvi et al., 2002; Azouvi et al., 2006; Halligan, Marshall, & Wade, 1989). For example, the most commonly used neuropsychological battery for SN, the Behavioral Inattention Test (Wilson, Cockburn, & Halligan, 1987), contains six paper-based tests. Many clinicians use neuropsychological test performance to infer patients' performance in activities of daily living (ADL). This practice is questionable, given that ADL are typically more complex than neuropsychological tests. ADL often require multitasking, while a neuropsychological test is usually focused on one single task (Bonato, Priftis, Umiltà, & Zorzi, 2013). Various behavioral signs shown in different neuropsychological tests may or may not provide a full picture of patients' functional impairment. For example, being unable to cross out targets in a cancellation test does not necessarily suggest specific difficulties in locating one's reading glasses, keys, or mobile phone in their living room. For this reason, direct observation of patients' performance during ADL helps clinicians to evaluate patients for SN signs from the perspective that is focused on the patients' functional ability and impairment in real-world situations. In short, direct observation during ADL provides clinically relevant information about patients' function that does not readily available or translatable from conventional test results, which are often exclusively focused on detecting specific SN signs.

The most used functional assessment for SN is the Catherine Bergego Scale (CBS). CBS is a 10-item, 4-point scale rated by examiners based on direct observation of patients' functioning in 10 real-life situations (Azouvi, 2017; Azouvi, 1996; Azouvi et al., 2003). Of the existing 28 standardized assessments (Menon & Korner-Bitensky, 2004), the CBS is the only one that may assess performance in all spatial sectors including the personal (i.e., the body surface), peripersonal (i.e., the space within the arm's reach), and also extrapersonal space (i.e., the space beyond the arm's reach), as well as assessing spatial errors in various processing stages (perceptual-attentional, representational, and motor-intentional; Barrett, 2013). The CBS has demonstrated a broad potential to assess heterogeneous signs of SN and the impact of different SN subtypes on ADL (Chen, Hreha, Fortis, Goedert, & Barrett, 2012; Goedert et al., 2012; Nijboer, Ten Brink, Kouwenhoven, & Visser-Meily, 2014). Chen and

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

colleagues (Chen et al., 2015; Chen et al., 2012) developed the Kessler Foundation Neglect Assessment Process (KF-NAP) as the standardized method to use the CBS in the inpatient rehabilitation setting. Many have used the KF-NAP since the first version was published, which made the CBS even more popular as a functional assessment for SN. However, there is still insufficient evidence whether the CBS via KF-NAP is a valid clinical tool.

In the present study, we explored the ability of the CBS via KF-NAP in detecting functional impairment related to SN especially in patients whose SN signs are considered mild or negligible in conventional neuropsychological tests. Specifically, we aimed to show that: (a) the CBS via KF-NAP selectively evaluate spatial rather than nonspatial dysfunctions; (b) the CBS via KF-NAP is more strongly correlated with scales that measure functional disability, especially motor-related functional impairment, than with conventional neuropsychological tests for SN; and (c) the CBS via KF-NAP is highly sensitive in detecting SN signs especially in those patients with mild severity.

Materials and Method

Participants

With the approval of the institutional ethical committee (*Nucleo per la Ricerca Clinica*) of the IRCCS San Camillo Hospital Foundation, Lido-Venice, Italy, we recruited 14 consecutive patients with first ever brain impairment that were hospitalized in a post-acute rehabilitation hospital (see Table 1 for demographic and clinical characteristics of the patients).

These patients had no history of dementia, substance abuse, and psychiatric disorders, and they showed no clinical signs or symptoms of anosognosia, anosodiaphoria, apathy-abulia, impersistence, and perseveration. All the patients had unilateral right-hemisphere lesions because of cerebrovascular accident or surgical operation, confirmed by computerized tomography (CT) or magnetic resonance imaging (MRI) scans. Visual field defects and visual extinction were also evaluated through bedside assessment. All the patients were right-handed and had no severe visual defect that compromise their performance in visuospatial tests. Patients were also administered the 21-item Italian version of the Depression Anxiety Stress Scale (DASS-21; Bottesi et al., 2015), and no patient met the clinical criterion for depression, anxiety, or stress.

Functional Assessment

To assess SN during functional activities, we used the CBS via KF-NAP (Chen, Chen, et al., 2015; Chen et al., 2012), 2014 version (Chen, Hreha, & Pitteri, 2014). The CBS is a 10-item scale with each item scored from 0 to 3, and a score of 0 is assigned for no neglect and 3 for severe neglect (Azouvi, 1996). The KF-NAP is a standardized, structured process of using the CBS. The KF-NAP provides item-by-item instructions on how to make observations and how to attribute scores. Two trained, independent assessors administered the CBS via KF-NAP to assess SN severity in limb awareness, personal belongings, dressing, grooming, gaze orientation, auditory attention, navigation, collisions, eating, and cleaning after meal.

Author Manuscript

Depending on patients' function level, it took 20 to 40 min to complete the CBS via KF-NAP.

To assess functional abilities, we administered the Barthel Index (BI; Mahoney & Barthel, 1965) and the Functional Independence Measure (FIM; Keith et al., 1987). BI is a 10-item scale and measures the extent to which someone can function independently in ADL (i.e., feeding, bathing, grooming, dressing, bowel control, bladder control, toileting, chair transfer, ambulation, and stair climbing). The BI is scored from 0 to 100 with higher values indicating greater function. FIM includes 18 items and two sub-scales, Motor FIM (13 items: eating, grooming, bathing, upper body dressing, lower body dressing, toileting, bladder management, bowel management, transfers— bed/chair/wheelchair, transfers for toilet, transfers for bath/shower, walk/wheelchair, or stairs) and Cognitive FIM (5 items: comprehension, expression, social interaction, problem solving, and memory). Each item is scored from 1 to 7 with higher values indicating greater independence.

Experienced neurologists completed the BI and FIM, while experienced neuropsychologists administered the CBS via KFNAP. Overall, examiners spent about 60 min to complete all three assessments.

Neuropsychological Assessment

Patients were assessed by experienced neuropsychologists using a set of neuropsychological tests for performance in specific spatial domains including personal, peripersonal, and extrapersonal space, and for imagined/mental spatial representation.

Personal space.—We assessed personal neglect with the Fluff test (Cocchini, Beschin, & Jehkonen, 2001). The test requires patients to remove 24 identical objects attached to the front of their upper-body clothes, evenly distributed on the left and right sides. Each object was a white, 2-cm-diameter circle made of cardboard with Velcro on one side. Patients performed the task with their ipsilesional arm (right arm) while blindfolded and seated securely without being informed on the total number of the objects attached to the clothes. The test was self-paced and not timed until patients reported that they had removed all the cardboards. The score was determined by the number of omissions in the left side. Thus, the maximal possible score was 12, and greater values indicated poor performance.

Peripersonal space.—We assessed peripersonal SN with the conventional part of the Behavioral Inattention Test (BIT-C; Wilson et al., 1987). The BIT-C is a standardized battery specifically designed to evaluate SN mainly in the peripersonal space, and includes six paper-based tasks: line crossing, letter cancellation, star cancellation, figure and shape copying, line bisection, and object drawings from memory. The score reflects the number of correct responses (in cancellation tasks) or performance (in line bisection or drawing); higher scores indicating better performance.

Extrapersonal space.—There are no standardized measures currently available to assess SN in the extrapersonal space. To overcome this limitation, we used the room description task based on Stone et al.'s study (Stone et al., 1991) with the same procedure successfully used in a previous study (Priftis, Passarini, Pilosio, Meneghello, & Pitteri, 2013). Patients

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

were asked to point or name all the objects they could see on both sides of a hospital room (7 × 4 m) where various objects were arranged symmetrically. Patients sat on their wheelchair in the center of the room, facing the longer side of the room. On each of the left and the right side, there were two chairs, two tables, a wastepaper basket, a dresser, a radiator, a window, a bookcase, and a low shelf. Responses were untimed. A correct response was scored with one point; the maximum score was 20.

Mental imagery space.—We assessed patients for the presence of SN in mental space with a combination of the original tasks described by Bisiach, Luzzatti, and Perani (1979) and Ogden (1985). The "Bisiach-Ogden test" (Priftis & Pitteri, 2014) consisted of 64 trials. During each trial, two symmetrical or asymmetrical red figures (see supplemental material for an example) were used: the asymmetrical figures was different from the symmetrical figure in its left or right half. The figures were about 7 X7.5 cm moved from left to right on a computer monitor (17 in.) at the speed of 5.5 cm/sec. The figures were only partially visible as they moved behind a vertical 4.5-cm wide "window" located in the center of the monitor. It took 1 to 1.5 s for each figure to cross the window completely. Three seconds after the first figure passed the window, the second figure moved in the same direction. In each trial, when the second figure disappeared, patients were required to say whether the two figures were the same or different. A lateralization score was calculated based only on trials where asymmetrical figures were presented, with the following formula: (correct responses for right-sided difference— correct responses for left- sided difference)/(correct responses for right-sided difference + correct responses for left-sided difference). Positive values indicate rightward bias, and negative values indicate leftward bias.

Neuropsychological tests for nonspatial cognitive functions.—Patients were also assessed with the Italian version of the Adden-brooke's Cognitive Examination–Revised (ACE-R; Pigliautile et al., 2011) to evaluate global cognitive functioning and a battery of neuropsychological tests for selective attention (Attention Matrices Test; Spinnler & Tognoni, 1987), executive functions (Phonemic Verbal Fluency Test; Novelli et al., 1986), language (Semantic Verbal Fluency Test and Verbal Naming Test; Novelli et al., 1986), short term memory and working memory (Digit Span Test; Monaco, Costa, Caltagirone, & Carlesimo, 2012), and long term memory (Rey 15-item Memory Test; Carlesimo et al., 1996). A detailed table of tests' results are available in supplemental material.

Composite Score Calculation

To obtain a unitary measure of asymmetry, we used an equation to calculate a lateralization index (LI) for each patient using tests examining peripersonal visuospatial function, including line cancellation, letter cancellation, star cancellation of the BIT-C (Wilson et al., 1987) and the percent of lateralized omissions in the Attention Matrices Test (Spinnler & Tognoni, 1987): (correct responses in the right-side— correct responses in the left-side)/ (correct responses in the right-side + correct responses in the left-side). Positive values indicate rightward bias, whereas negative values indicate leftward bias.

We also calculated the mean of equivalent scores (ES) of the neuropsychological tests for nonspatial function, including the Verbal Naming Test (Novelli et al., 1986), the Phonemic and Semantic Verbal Fluency Tests (Novelli et al., 1986), the Digit Span Test (Monaco et al., 2012), and the Rey 15-item Memory Test (Carlesimo et al., 1996).

Results

The CBS via KF-NAP Selectively Evaluate Spatial Dysfunctions

A multiple regression analysis with the LI and ES scores as predictors of the CBS via KF-NAP showed a significant effect of the LI, $\beta = .194$, $t(11) = 3.576$, $p = .004$, but did not yield a significant effect of the ES, $\beta = 1.507$, $t(11) = .964$, $p = .356$. This suggests that the CBS via KF-NAP aligns with the observation of lateralized visuospatial functions, instead of nonspatial functions.

The CBS via KF-NAP is More Strongly Correlated With Scales That Measure Functional Disability Than With Conventional Neuropsychological Tests for SN

We found that the CBS via KF-NAP had moderate to strong negative correlations with the BIT-C, rs (14) = −.668, $p = .009$, with the BI, r_s (14) = −.700, $p = .005$, and with the FIM, $r_s(14) = -.662$, $p = .01$, indicating correlations between the extent of SN severity and the degree of functional disability. It is worth to note, however, that the total score of the FIM is the result of items that fall into two main categories: motor (13 items) and cognitive (5 items). In this respect, we found that the CBS via KF-NAP had strong negative correlation with the Motor FIM, $r_s(14) = -.729$, $p = .003$, whereas the CBS via KF-NAP had weak negative correlation with the Cognitive FIM r_s (14) = .366, $p = .198$.

To further investigate these correlations and to determine if the CBS via KF-NAP was more or less correlated with the BIT-C, the BI, the Motor FIM, and the Cognitive FIM scores, we ran a stepwise regression analysis that showed that the Motor FIM was the only significant predictor of the CBS via KF-NAP, $\beta = .180$, $t(12) = -3.766$, $p = .003$. All the other predictors did not reach significance ($p > .05$).

The CBS via KF-NAP Is Highly Sensitive in Detecting SN Signs Especially in Those Patients With Mild Severity

Table 2 shows the number (%) of the 14 patients who failed each test according to its cut-off score for the SN diagnosis. Only 1 patient (7%) failed the Bisiach-Ogden Test (SN in mental im-agery), 2 patients (14%) failed the Fluff Test (personal SN), and 5 patients (36%) failed the BIT-C (peripersonal SN). On the contrary, considering the CBS via KF-NAP, 11 patients (79%) showed SN. The patients who failed the Bisiach-Ogden Test and the Fluff Test also failed the BIT-C, suggesting that, at least in our sample of SN patients, the BIT-C was able to detect SN also in patients who had spatial deficits also in other spatial domains in addition to the peripersonal space. On the contrary, the CBS via KF-NAP captured all the patients identified by the BIT-C. It is worth to note that all the patients that failed the BIT-C also failed in the CBS via KF-NAP, but not vice versa, suggesting that the CBS via KF-NAP cover all aspects of SN. To support this observation statistically, a χ^2analysis between the percentage of patients who manifested SN in the CBS via KF-NAP with respect to the BIT-C yielded a significant difference, $Z = -2.45$, $p = .014$. Thus, the CBS was more sensitive than BIT-C in detecting SN.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Patients who were not identified by the BIT-C but were by the CBS via KF-NAP had a median BIT-C score of 140 (IQR = 134 –141) comparing with patients who were identified by both assessments (median = 104, IQR = 91.5–120.5). The significant difference was confirmed by the *U* test, $Z = -2.75$, $p = .004$. This indicated that the former group had milder symptoms or signs of SN that could not be detected by the BIT-C but was captured by the CBS via KF-NAP. This result is aligned with our hypothesis that the CBS via KF-NAP is highly sensitive in detecting SN signs especially in those patients with mild severity.

Discussion

The present study showed that the CBS via KF-NAP is able to detect functional impairment related to SN, especially in patients whose SN signs are considered mild or negligible in conventional neuropsychological tests. Specifically, the findings suggest that: (a) the CBS via KF-NAP selectively evaluate spatial dysfunctions; (b) the CBS via KF-NAP is more strongly correlated with scales that measure functional disability, especially motor-related functional impairment, than with conventional neuropsychological tests for SN; and (c) the CBS via KF-NAP is highly sensitive in detecting SN signs especially in those patients with mild severity, covering several aspects of SN manifestations. Although further studies are needed in larger, representative groups of patients with cerebral lesions with and without SN, our results suggest that the CBS via KF-NAP may be a valuable functional measure that examines specifically the visuospatial domain, rather than being a general measure of patients' performance affected by various factors. Nonetheless, as shown in the present and also previous studies, signs and symptoms of SN can vary in a given patient depending on the test used, the test's nature, and the test's complexity. Other concurrent factors unrelated to the test, such as fatigue, motivation, or mood state, may affect test results. In addition, within various functions of attention, components of nonspatial attention should be evaluated as well; although the majority of previous studies have focused on the lateralized components of SN, recent results have also revealed deficits that are not spatially lateralized and can interact with the presentation of SN signs (see Husain & Rorden, 2003; Priftis, Bonato, Zorzi, & Umiltà, 2013). For example, vigilance, sustained attention, apathy, abulia, and perseveration are related to nonspatial attention. We did not collect such information in the present study. Future studies should explicitly take nonspatial attention into account when examining patients for SN.

Consistent with previous studies, using the KF-NAP procedures to perform the CBS, we found correlations between the CBS and the FIM, and between the CBS and the BI (Azouvi et al., 2006; Chen et al., 2015; Qiang, Sonoda, Suzuki, Okamoto, & Saitoh, 2005). Thus, our results confirm the relationship between SN severity (indicated by the CBS via KF-NAP) and functional disability (indicated by FIM and BI). Moreover, we found that the SN severity correlated with motor-related disability (indicated by Motor FIM subscale), rather than social or cognitive related dysfunction (indicated by Cognitive FIM subscale). This is consistent with the data of Goedert et al. (2012) showing that some CBS items potentially correspond to motor-exploratory deficits as assessed by the BI. Thus, clinicians should be aware that functional impairment related to SN can be an obstacle to motor functional recovery in rehabilitation settings (Chen, Hreha, Kong, & Barrett, 2015; Nijboer, Kollen, & Kwakkel, 2014).

Author Manuscript

Even though the CBS via KF-NAP and the BIT-C correlated with each other and even though they both correlated with functional measures of disability (i.e., BI and FIM), assessing patients with CBS via KF-NAP permits to cover all spatial domains in one evaluation (personal, peripersonal, extrapersonal, and mental imagery), which is uniquely different from the BIT-C. Thus, the CBS via KF-NAP is considered a valuable instrument for the comprehensive detection of different aspects of SN related to ADL (see also Azouvi et al., 2003). The CBS via KF-NAP may help integrate the heterogeneity of SN signs as they affect functional tasks, and this may be the reason why the CBS via KF-NAP is more sensitive than conventional tests to detect SN.

Previous studies reported different level of sensitivity of the CBS in detecting SN among a group of individuals with right-hemisphere stroke: 94% (Azouvi, 2017), 76.8% (Azouvi et al.,2002), 96.4% (Azouvi et al., 2003), and 77.3% (Azouvi et al., 2006), the highest among all the tests used in each study. The present study showed the CBS via KF-NAP a 79% of detection rate, also the highest sensitivity among all the SN tests included in the study. Thus, in line with Azouvi and colleagues' studies (Azouvi, 1996; Azouvi et al., 2003, 2006; Azouvi et al., 2002), functional assessments such as the CBS via KF-NAP are more sensitive to the presence of SN than any conventional paper-based test. This suggests that the diagnosis of SN should not be ruled out based on the normal performance on paper-based tests alone, without a careful examination of how patients behave in their real environment (Azouvi et al., 2006).

We are aware that the CBS is not without limitations. One may criticize that the CBS is subjective as all examiner-rated scales are, and score assignment could vary from examiner to examiner (e.g., different examiners have varied knowledge of a given patient's history). However, this is why the KF-NAP was developed, which was to standardize observation procedures and scoring methods (Chen et al., 2012). Nonetheless, future studies with blinded examiners may help address this issue.

Another common limitation of the KF-NAP shared with other assessments is that functional assessment often consists of tasks simulating real-life situations. Thus, patients' behaviors observed during assessment, albeit in their actual everyday environment, are not truly the same as their behaviors occur without being observed. It is possible that following instructions (e.g., "show me how you put on this jacket") may lead to a behavior demonstrating spatial deficits that are different from spatial deficits of spontaneous behavior. Thus, it is important that clinicians observe patients regularly and pay attention to patients' spontaneous behavior, which always provide critical information guiding clinical judgment.

The results of our preliminary, small-sample study suggest that assessment of functional performance with the CBS via KF-NAP may identify more patients with functionally relevant SN. Adding the BIT-C may further improve the specificity of assessment, and the ability to detect functionally relevant cognitive deficits. Given the considerable morbidity associated with SN after stroke and brain injury (Chen, Chen, et al., 2015; Chen, Ward, Khan, Liu, & Hreha, 2016), a larger study of a representative sample of brain-lesioned patients, including patients with and without SN, and specifically assessing the sensitivity and specificity of the CBS via KF-NAP and the BIT-C, is definitely warranted. For instance,

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

further studies on this topic might examine consecutive left- and right-hemisphere lesioned patients looking at the frequency of patients with and without SN, to determine the degree to which approaches (i.e., BIT-C and the CBS via KF-NAP) are assessing SN specifically versus the more generalized aspects of left- and right-hemisphere dysfunction.

Conclusions and Clinical Implications

There is a need for standardized ecological measures of SN to quantify the extent of SN in everyday life, to adapt rehabilitation to the individual patient's limitations, to monitor changes, and to assess the effectiveness of rehabilitation (Azouvi, 2017; Chen, Pitteri, Gillen, & Ayyala, 2017). A recent Cochrane review reported the urge to look at disability outcomes rather than SN impairment tests (Bowen, Hazelton, Pollock, & Lincoln, 2013). This last point is of great importance for rehabilitation studies, which are often limited by the lack of evidence of any therapeutic effect on everyday life.

It is essential to diagnose SN using adequately sensitive measures. We suggest that a functional assessment like the CBS via KF-NAP might be directly relevant to motor disability after brain lesions. The CBS via KF-NAP might also detect a range of SN deficits that are difficult to identify with conventional tests, and it can be combined with other functional assessments, increasing time-efficiency in care. Currently there is no consensus on the gold standard of SN diagnosis. We argue that the CBS via KF-NAP may be a good candidate for the following reason. If the patient's behavior is functionally disabling as measured using the CBS via KF-NAP, then the patient's SN diagnosis based on the CBS score is clinically important and directly relevant to care planning and goal setting.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

AMB was funded by the Kessler Foundation, the Wallerstein Foundation for Geriatric Improvement, the National Institute for Disability, Independent Living and Rehabilitation Research (901F0037), and the National Institutes of Health (K24HD062647). Readers should not assume endorsement of this report by the federal government. We thank Prof. Konstantinos Priftis for his helpful comments on an early version of the manuscript.

References

Azouvi P (2017). The ecological assessment of unilateral neglect Annals of Physical and Rehabilitation Medicine France: Elsevier Masson 10.1016/j.rehab.2015.12.005

Azouvi P, Bartolomeo P, Beis J-M, Perennou D, Pradat-Diehl P, … Rousseaux M (2006). A battery of tests for the quantitative assessment of unilateral neglect. Restorative Neurology and Neuroscience, 24, 273–285. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17119304 [PubMed: 17119304]

Azouvi P (1996). Functional consequences and awareness of unilateral neglect: Study of an evaluation scale. Neuropsychological Rehabilitation, 6, 133–150. 10.1080/713755501

Azouvi P, Olivier S, de Montety G, Samuel C, Louis-Dreyfus A, Tesio L (2003). Behavioral assessment of unilateral neglect: Study of the psychometric properties of the Catherine Bergego Scale. Archives of Physical Medicine and Rehabilitation, 84, 51–57. 10.1053/apmr.2003.50062 [PubMed: 12589620]

Author Manuscript

Azouvi P, Samuel C Louis-Dreyfus, Bernati A, Bartolomeo T, Beis P, J.-M., . Rousseaux M. (2002). Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke. Journal of Neurology, Neurosurgery, and Psychiatry, 73, 160 –166. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1737990&tool=pmcentrez&rendertype=abstract

Barrett AM (2013). Perceptual-attentional "where" and motorintentional "aiming" spatial systems. In the roots of cognitive neuroscience: Behavioral neurology and neuropsychology 10.1093/acprof:oso/9780195395549.003.0008

Barrett AM, Burkholder S (2006). Monocular patching in subjects with right-hemisphere stroke affects perceptual-attentional bias. Journal of Rehabilitation Research and Development, 43, 337–346. 10.1682/JRRD.2005.01.0015 [PubMed: 17041819]

Beis J-M, Keller C, Morin N, Bartolomeo P, Bernati T, Chokron S,… the French Collaborative Study Group on Assessment of Unilateral Neglect (GEREN/GRECO). (2004). Right spatial neglect after left hemisphere stroke: Qualitative and quantitative study. *Neurology*, 63, 1600 1605. 10.1212/01.WNL.0000142967.60579.32 [PubMed: 15534242]

Bisiach E, Luzzatti C, Perani D (1979). Unilateral neglect, representational schema and consciousness. Brain: A Journal of Neurology, 102, 609 618. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/497807 ; http://www.ncbi.nlm.nih.gov/pubmed/49780710.1093/brain/102.3.609; http://dx.doi.org/10.1093/brain/102.3.609 [PubMed: 497807]

Blini E, Romeo Z, Spironelli C, Pitteri M, Meneghello F, Bonato M, Zorzi M (2016). Multi-tasking uncovers right spatial neglect and extinction in chronic left-hemisphere stroke patients. Neuropsychologia,92, 147–157. 10.1016/j.neuropsychologia.2016.02.028 [PubMed: 26948071]

Bonato M, Deouell LY (2013). Hemispatial neglect: Computer-based testing allows more sensitive quantification of attentional disorders and recovery and might lead to better evaluation of rehabilitation.Frontiers in Human Neuroscience, 7, 162. [PubMed: 23641207]

Bonato M, Priftis K, Marenzi R, Umiltà C, Zorzi M (2010). Increased attentional demands impair contralesional space awareness following stroke. Neuropsychologia, 48, 3934 –3940. 10.1016/j.neuropsychologia.2010.08.022 [PubMed: 20801136]

Bonato M, Priftis K, Marenzi R, Umiltà C, Zorzi M (2012). Deficits of contralesional awareness: A case study on what paper-and- pencil tests neglect. Neuropsychology, 26, 20 –36. 10.1037/a0025306 [PubMed: 21895377]

Bonato M, Priftis K, Umiltà C, Zorzi M (2013). Computer-based attention-demanding testing unveils severe neglect in apparently intact patients. Behavioural Neurology, 26, 179 –181. 10.1155/2013/139812 [PubMed: 22713418]

Bottesi G, Ghisi M, Altoè G, Conforti E, Melli G, Sica C (2015). The Italian version of the Depression Anxiety Stress Scales-21: Factor structure and psychometric properties on community and clinical samples. Comprehensive Psychiatry, 60, 170 –181. 10.1016/j.comppsych.2015.04.005 [PubMed: 25933937]

Bowen A, Hazelton C, Pollock A, Lincoln NB (2013). Cognitive rehabilitation for spatial neglect following stroke. In Bowen A (Ed.), Cochrane database of systematic reviews (p. CD003586). Chichester, U. K.: Wiley, Ltd 10.1002/14651858.CD003586.pub3

Buxbaum LJ, Ferraro MK, Veramonti T, Farne A, Whyte J, Ladavas E, Coslett HB, (2004). Hemispatial neglect: Subtypes, neuroanatomy, and disability. Neurology, 62, 749 –756. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15007125 [PubMed: 15007125]

Carlesimo GA, Caltagirone C, Gainotti G, Fadda L, Gallassi R, Lorusso S, . . . The Group for the Standardization of the Mental Deterioration Battery. (1996). The Mental Deterioration Battery: Normative data, diagnostic reliability and qualitative analyses of cognitive impairment. European Neurology, 36, 378 –384. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8954307 ; http://www.ncbi.nlm.nih.gov/pubmed/895430710.1159/000117297; http://dx.doi.org/10.1159/000117297 [PubMed: 8954307]

Chen P, Chen CC, Hreha K, Goedert KM, Barrett AM (2015). Kessler Foundation neglect assessment process uniquely measures spatial neglect during activities of daily living. Archives of Physical Medicine and Rehabilitation, 96, 869 876. 10.1016/j.apmr.2014.10.023 [PubMed: 25461827]

Chen P, Hreha K, Fortis P, Goedert KM, Barrett AM (2012). Functional assessment of spatial neglect: A review of the Catherine Bergego scale and an introduction of the Kessler foundation neglect assessment process. Topics in Stroke Rehabilitation, 19, 423– 435. 10.1310/tsr1905-423 [PubMed: 22982830]

Chen P, Hreha K, Kong Y, Barrett AM (2015). Impact of spatial neglect on stroke rehabilitation: Evidence from the setting of an inpatient rehabilitation facility. Archives of Physical Medicine and Rehabilitation, 96, 1458 –1466. 10.1016/j.apmr.2015.03.019 [PubMed: 25862254]

Chen P, Hreha K, Pitteri M (2014). Kessler Foundation Neglect Assessment Process: KF-NAP 2014 Manual Retrieved from https://kesslerfoundation.org/sites/default/files/files/KF-NAP_2014_Manual_double-sided_printing.pdf

Chen P, Pitteri M, Gillen G, Ayyala H (2017). Ask the experts how to treat individuals with spatial neglect: A survey study. Disability and Rehabilitation 10.1080/09638288.2017.1347720

Chen P, Ward I, Khan U, Liu Y, Hreha K (2016). Spatial neglect hinders success of inpatient rehabilitation in individuals with traumatic brain injury: A retrospective study. Neurorehabilitation and Neural Repair, 30, 451– 460. 10.1177/1545968315604397 [PubMed: 26338431]

Cocchini G, Beschin N, Jehkonen M (2001). The Fluff Test: A simple task to assess body representation neglect. Neuropsychological Rehabilitation, 11, 17–31. 10.1080/09602010042000132

Goedert KM, Chen P, Botticello A, Masmela JR, Adler U, Barrett AM (2012). Psychometric evaluation of neglect assessment reveals motor-exploratory predictor of functional disability in acute- stage spatial neglect. Archives of Physical Medicine and Rehabilitation, 93, 137–142. 10.1016/j.apmr.2011.06.036 [PubMed: 22200393]

Halligan PW, Marshall JC, Wade DT (1989). Visuospatial neglect: Underlying factors and test sensitivity. The Lancet, 334, 908 911. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2571823 ; http://www.ncbi.nlm.nih.gov/pubmed/257182310.1016/S0140-6736(89)91561-4; http://dx.doi.org/10.1016/S0140-6736(89)91561-4

Heilman KM, Watson RT, Valenstein E (2003, 2). Neglect and related disorders Retrieved from http://www.us.oup.com/us/catalog/general/subject/Medicine/Neuropsychology/?view=usa&sf=toc&ci=9780195133677

Hreha K, Mulry C, Gross M, Jedziniak T, Gramas N, Ohevshalom L, . Barrett, A. M. (2016). Assessing chronic stroke survivors with aphasia sheds light on prevalence of spatial neglect. Topics in Stroke Rehabilitation, 34, 91–98.

Husain M, Rorden C (2003). Non-spatially lateralized mechanisms in hemispatial neglect. Nature Reviews Neuroscience, 4, 26 –36. 10.1038/nrn1005 [PubMed: 12511859]

Jehkonen M, Ahonen JP, Dastidar P, Koivisto AM, Laippala P, Vilkki J, Molnár G (2001). Predictors of discharge to home during the first year after right hemisphere stroke. Acta Neurologica Scandinavica, 104, 136 –141. Retrieved from http://www.ncbi.nlm.nih.gov/ pubmed/11551232 ; http://www.ncbi.nlm.nih.gov/ pubmed/1155123210.1034/j.1600-0404.2001.00025.x; http://dx.doi.org/10.1034/j.1600-0404.2001.00025.x [PubMed: 11551232]

Katz N, Hartman-Maeir A, Ring H, Soroker N (1999). Functional disability and rehabilitation outcome in right hemisphere damaged patients with and without unilateral spatial neglect. Archives of Physical Medicine and Rehabilitation, 80, 379 –384. 10.1016/S0003-9993(99)90273-3 [PubMed: 10206598]

Keith RA, Granger CV, Hamilton BB, Sherwin FS (1987). The functional independence measure: A new tool for rehabilitation. Advances in Clinical Rehabilitation, 1, 6 –18. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3503663 [PubMed: 3503663]

Kleinman JT, Newhart M, Davis C, Heidler-Gary J, Gottesman RF, Hillis AE (2007). Right hemispatial neglect: Frequency and characterization following acute left hemisphere stroke. Brain and Cognition, 64, 50 –59. 10.1016/j.bandc.2006.10.005 [PubMed: 17174459]

Mahoney FI, Barthel DW (1965). Functional evaluation: The barthel index. Maryland State Medical Journal, 14, 61– 65. 10.1016/S0140-6736(10)62108-3

Menon A, Korner-Bitensky N (2004). Evaluating unilateral spatial neglect post stroke: Working your way through the maze of assessment choices. Topics in Stroke Rehabilitation, 11, 41– 66. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15480953 ; http://www.ncbi.nlm.nih.gov/pubmed/1548095310.1310/KQWL-3HQL-4KNM-5F4U; http://dx.doi.org/10.1310/KQWL-3HQL-4KNM-5F4U [PubMed: 15480953]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Author Manuscript

Monaco M, Costa A, Caltagirone C, Carlesimo GA (2012). Forward and backward span for verbal and visuo-spatial data: Standardization and normative data from an Italian adult population. Neurological Sciences: Official Journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology, 34, 749 –754. 10.1007/s10072-012-1130-x

Nijboer TCW, Ten Brink AF, Kouwenhoven M, Visser-Meily JMA (2014). Functional assessment of region-specific neglect: Are there differential behavioural consequences of peripersonal versus extrapersonal neglect? Behavioural Neurology. [Advance online publication.]

Nijboer TCW, Kollen BJ, Kwakkel G (2013). Time course of visuospatial neglect early after stroke: A longitudinal cohort study. Cortex, 49, 2021–2027. 10.1016/j.cortex.2012.11.006 [PubMed: 23332473]

Nijboer TCW, Kollen BJ, Kwakkel G (2014). The impact of recovery of visuo-spatial neglect on motor recovery of the upper paretic limb after stroke. PLoS ONE, 9, e100584 10.1371/journal.pone.0100584 [PubMed: 24950224]

Novelli G, Papagno C, Capitani E, Laiacona M, Vallar G, Cappa SF (1986). Tre test clinici di ricerca e produzione lessicale. Taratura su sogetti normali [Three clinical tests to research and rate the lexical performance of normal subjects]. Archivio di Psicologia, Neurologia, e Psichiatria, 47, 477–506.

Ogden JA (1985). Contralesional neglect of constructed visual images in right and left brain-damaged patients. Neuropsychologia, 23, 273–277. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/4000463; http:// dx.doi.org/10.1016/0028-3932(85)90112-5 [PubMed: 4000463]

Pigliautile M, Ricci M, Mioshi E, Ercolani S, Mangialasche F, Monastero R, . Mecocci P (2011). Validation study of the Italian Addenbrooke's Cognitive Examination Revised in a young-old and old-old population. Dementia and Geriatric Cognitive Disorders, 32, 301–307. 10.1159/000334657 [PubMed: 22262124]

Priftis K, Pitteri M (2014). The "Bisiach-Ogden test", unpublished data

Priftis K, Bonato M, Zorzi M, Umiltà C. (2013). Spatial and non-spatial aspects of neglect. Frontiers in Human Neuroscience, 7, 25 10.3389/fnhum.2013.00025 [PubMed: 23386825]

Priftis K, Passarini L, Pilosio C, Meneghello F, Pitteri M (2013). Visual scanning training, limb activation treatment, and prism adaptation for rehabilitating left neglect: Who is the winner? Frontiers in Human Neuroscience, 7, 360. [PubMed: 23847520]

Qiang W, Sonoda S, Suzuki M, Okamoto S, Saitoh E (2005). Reliability and validity of a wheelchair collision test for screening behavioral assessment of unilateral neglect after stroke. American Journal of Physical Medicine & Rehabilitation/Association of Academic Physiatrists, 84, 161–166. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15725789

Riestra AR, Barrett AM (2013). Rehabilitation of spatial neglect.Handbook of Clinical Neurology, 110, 347–355. 10.1016/B978-0-444-52901-5.00029-0 [PubMed: 23312654]

Schendel KL, Robertson LC (2002). Using reaction time to assess patients with unilateral neglect and extinction. Journal of Clinical and Experimental Neuropsychology, 24, 941–950. 10.1076/jcen.24.7.941.8390 [PubMed: 12647770]

Spinnler H, Tognoni G (1987). Standardizzazione e taratura italiana di test neuropsicologici. Italian Journal of Neurological Sciences, 6(Suppl. 8), 8 –72.

Stone SP, Wilson B, Wroot A, Halligan PW, Lange LS, Marshall JC, Greenwood RJ (1991). The assessment of visuo-spatial neglect after acute stroke. Journal of Neurology, Neurosurgery, and Psychiatry, 54, 345–350. 10.1136/jnnp.54.4.345

Wilson B, Cockburn J, Halligan P (1987). Development of a behavioral test of visuospatial neglect. Archives of Physical Medicine and Rehabilitation, 68, 98 –102. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3813864 [PubMed: 3813864]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

General Scientific Summary

Improving diagnostic process is of paramount importance to detect even subtle spatial neglect signs. This is relevant not only for assessment, but also for rehabilitation. We showed that both conventional and functional assessments, carried out together, could provide a useful examination strategy of spatial neglect deficits.

Author Manuscript
Author Manuscript
Author Manuscript
Author Manuscript

Table 1

Demographic and Clinical Characteristics of the Studied Patients

Patient	Gender	Age (years) *M* = 61.3, *SD* = 15	Education (years) *M* = 12.4, *SD* = 5.2	Visual extinction	Visual field defects
1	M	54	18	−	−
2	M	65	17	−	−
3	M	80	13	−	−
4	M	58	13	+	−
5	F	63	13	−	LIQ
6	F	77	10	+	−
7	M	79	8	+	−
8	M	60	13	na	LHH
9	F	42	8	+	LIQ
10	F	72	12	−	−
11	M	29	16	−	−
12	M	75	2	−	−
13	F	56	8	na	LHH
14	F	48	23	na	LHH

Note. M = male; F = female; "+" = present;"−" = absent; LIQ = left inferior quadrantanopia; LHH = left homonymous hemianopia; na = not available because of LHH. All of them had right-hemisphere damage.

Author Manuscript
Author Manuscript
Author Manuscript
Author Manuscript

Table 2

Total Number of Patients Diagnosed as Having SN in One or More Spatial Domains

Patient	Functional SN (KF-NAP)	Peripersonal SN (BIT-C)	Personal SN (Fluff Test)	Imaginal SN (Bisiach-Ogden Task)
1	−	−	−	−
2	+	+	−	−
3	+	−	−	−
4	+	−	−	na
5	+	−	−	−
6	+	+	+	−
7	+	+	−	−
8	+	−	−	−
9	−	−	−	−
10	+	−	−	−
11	−	−	−	−
12	+	+	+	+
13	+	+	−	na
14	+	−	−	−
Total	11	5	2	1
%	79	36	14	7

Note. SN = spatial neglect; na = not available; KF-NAP = Kessler Foundation Neglect Assessment Process; BIT-C = conventional part of the Behavioral Inattention Test; "+" = present;"−" = absent. The results about the room description test are not displayed because normative data are not available for that test.