Archives of Clinical Neuropsychology, 2026, **41**(3), acag018
https://doi.org/10.1093/arclin/acag018
Published: 24 March 2026
Original Empirical Article

OXFORD

NeBa - Neglect battery: updated norms, new scores, and guidelines of a neuropsychological battery for the assessment of unilateral spatial neglect and associated disorders

Francesca Crespi[1,2], Irene Rossi[3], Lorenzo Diana[3,4], Paola Fortis[3], Giuseppe Vallar[3], Nadia Bolognini[2,3,*], Roberta Ronchi[5,6,7]

[1]Ph.D. Program in Neuroscience, School of Medicine and Surgery, University of Milano-Bicocca, Monza, MB, Italy
[2]Department of Psychology, University of Milano-Bicocca, Milan, MI, Italy
[3]Laboratory of Neuropsychology, Department of Neurorehabilitation Sciences, IRCCS Istituto Auxologico Italiano, Milan, MI, Italy
[4]Swiss Paraplegic Research, Nottwil, LU, Switzerland
[5]Department of Clinical Neurosciences, Faculty of Medicine, University of Geneva, Geneva, GE, Switzerland
[6]Department of Clinical Neurosciences, Neurology service, University Hospital of Geneva, Geneva, GE, Switzerland
[7]NEURO@campusbiotech, Campus Biotech, Geneva, Switzerland
*Corresponding author at: Laboratory of Neuropsychology, IRCCS Istituto Auxologico Italiano, Milano, Italy. Tel.: +39 026643822.
E-mail address: n.bolognini@auxologico.it (N. Bolognini).

ABSTRACT

Aim: Neuropsychological tests of visuo-spatial exploration, line bisection, and drawing are typically employed for diagnosing unilateral spatial neglect (USN), but updated norms, including those for left and right biases, are still lacking. This study aims to standardize administration and scoring of the most widely used USN tests, providing regression-based norms and equivalent scores (ES) of a comprehensive set of old and new visuo-spatial indexes. These include asymmetry in the allocentric and egocentric spaces, execution times, as well as measures of productive symptoms (e.g., perseverations) and constructional apraxia in an Italian sample.
Methods: A sample of 270 neurologically healthy participants (139 females, mean age: 60.57 ± 12.79 years) completed a neuropsychological battery including line bisection, line/star/geometrical item cancellations, copy of simple and complex drawings, the clock drawing test, and a new representational neglect test. Multiple regressions estimated the effects of age, education, and gender. Non-parametric tolerance limits and ES were calculated on ranked adjusted scores.
Results: Regression analyses showed significant influences of age and education across tasks; both predicted execution time and spatial asymmetry in cancellations, constructional apraxia in drawings, and clock drawing accuracy. Education specifically predicted perseverations in cancellations, while age specifically predicted cancellation accuracy and perseverations in drawing tasks. Gender only influenced line bisection and, along with age and education, accuracy in the butterfly memory test.
Discussion: This work provides updated norms for standard and novel visuo-spatial indexes in the assessment of USN and associated disorders, with standardized procedures to guide clinical assessment and support neglect rehabilitation.

Keywords: neuropsychological tests; unilateral spatial neglect; visuo-spatial deficit; constructional apraxia

Received: 8 September 2025. **Revised:** 13 January 2026. **Accepted:** 10 February 2026.
© The Author(s) 2026. Published by Oxford University Press.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com.

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Introduction

Unilateral Spatial Neglect (USN) is a neuropsychological syndrome featuring difficulty in paying attention to, interacting with and reporting events from the contralesional hemispace, which is not caused by lower-level sensory, motor disorders, or both (Heilman & Valenstein, 1979; Vallar & Ronchi, 2022). USN most commonly results from acquired brain lesions involving intra- and inter-hemispheric connections with temporo-parietal circuits of the right hemisphere, causing impairments in the contralateral left side of space (Corbetta & Shulman, 2011; Lunven & Bartolomeo, 2017; Vallar & Perani, 1986).

The view that USN is a unitary disorder was questioned by findings showing that patients may exhibit evidence of USN in one but not in another task, putatively assessing the same disorder. These double dissociations are evidence that two independent processes are involved in the two tasks (Vallar, 2000). In extra-personal space and in the tasks for which the present study provides norms, patients may show left USN in line bisection but not in target cancellation, and vice versa (Halligan & Marshall, 1993), in visuo-spatial mental images but not in physical extra-personal space and vice versa (Anderson, 1993; Bisiach et al., 1981; Coslett, 1997; Guariglia et al., 1993). More generally, as a multi-componential disorder, USN may manifest in different sectors of space: personal space (the patient's own body); peri-personal or near extra-personal space (within arm reach); far extra-personal space (beyond arm reach); imaginal (mental images) and physical space. USN may also manifest in different sensory modalities, jointly or separately (e.g., visual vs. tactile, De Renzi et al., 1970; Pierce et al., 2022; Vallar et al., 1991). Other dimensions include spatial reference frames. Egocentric USN (body-centered, viewer-centered) is defined relative to the body or to the body parts, namely the mid-sagittal plane, the eyes, the head, and the hand, whereas allocentric USN is defined relative to the intrinsic axes of the object (Halligan et al., 2003; Vallar & Bolognini, 2014; Vallar & Maravita, 2009; Vallar & Ronchi, 2022; e.g., neglect dyslexia, Vallar et al., 2010). Along an input/output dichotomy, a distinction has been drawn between perceptual and premotor components of USN. Perceptual USN refers to the inability to consciously perceive, and consequently report, stimuli located on the contralateral side of space. Premotor neglect includes two different deficits, unilateral directional hypokinesia and akinesia (Coslett et al., 1990; Husain et al., 2000; Sapir et al., 2007), and refers to the failure to execute movements, fully or partially, towards the contralateral hemispace, even when using the unaffected limbs (the upper limb is typically assessed). This disorder has been investigated using experimental variants of the line bisection task, such as indirect viewing of the line through a video camera and a monitor, each of which could be moved independently into the right or left side of space (Coslett et al., 1990). Similar manipulations have been applied to the line cancellation task, in which the direct view of the stimuli is also prevented through a 90° angled looking glass (Tegnér & Levander, 1991). However, these methods are too complex to be implemented as tests suitable for clinical assessment. A test putatively assessing perceptual and response biases is the Landmark Task (Milner et al., 1993), in which participants judge the relative length (shorter/longer) of pre-bisected line segments. In right brain-damaged patients with left USN, a rightward bias in all conditions suggests a contralateral directional hypokinesia. Conversely, directional biases related to the segment length and required responses suggest a perceptual bias. Normative data for a variant of Milner et al.'s (1993) task have been collected in healthy participants by Capitani et al. (2000). Finally, another type of output-related deficit sometimes discussed in the context of USN is motor neglect, the inability to perform movements using the contralateral limbs, mimicking a primary motor deficit (Laplane & Degos, 1983).

In addition to the previously-mentioned "defective" signs, such as failing to explore the contralateral side of space, USN patients may also show "productive" manifestations. The distinctive feature of such manifestations is, rather than the lack of behaviours appropriate to the situation, the production of gratuitous actions, such as graphic perseverations or the manifestation of delusional beliefs that are inappropriate with respect to the setting (Vallar, 1998; Vallar & Calzolari, 2018). One of the most frequent productive phenomena, usually shown in target cancellation and drawing tasks, is the presence of perseverations. These have been distinguished in simple forms, which are the tendency to overscore a target already drawn, and complex forms, which are extra productions, such as drawing new targets, or other unrelated graphical productions (e.g., the signature). Neurological patients can show neglect errors (i.e., omissions) without perseverations, and vice versa; omissions and perseveration errors do not seem to correlate (Pia et al., 2009; Rusconi et al., 2002; Vallar et al., 2006). About one third of patients with unilateral spatial neglect show simple recurring perseverations in target cancellation tasks (Na et al., 1999; Nys et al., 2006), with the stimulus type and spatial disposition influencing their occurrence (Ronchi et al., 2012). Moreover, perseverative errors could also be found in drawing, especially in memory conditions, suggesting that visuo-exploratory task with fewer constraints elicit more productive symptoms (Ronchi et al., 2009). Despite their co-occurrence, the presence of double dissociations, the absence of correlation between defective and productive manifestations, and their different neural substrates suggest that defective and productive behaviours in USN may reflect two distinct mechanisms: perseveration appears to be associated with defective response inhibition, whereas omissions are linked to an ipsilesional bias of spatial attention and representation, which may trigger and facilitate the presence of productive behaviours (Ronchi et al., 2009).

Another frequent visuo-spatial disorder following brain damage is constructional apraxia. This deficit, which can be caused by right and left brain lesions, is characterized by a patient's inability to assemble or construct objects-whether drawing, building, or arranging items-in space (Russell et al., 2010). Like some manifestations of USN, constructional apraxia involves an altered processing which is object-based, but does not impact one specific part of the space. It can be underdiagnosed in clinical settings (Demeyere & Gillebert, 2019) and often is not the first focus of rehabilitation programs (Okamoto & Mano, 2023).

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Interestingly, this disorder can be disregarded in the acute phase of the brain lesion, when visuo-spatial neglect signs are more prevalent and disabling, but it may persist pervasively in the chronic phase of the disease after the improvement or recovery of USN (Song et al., 2025). By consequence, a correct detection of constructional apraxia manifestations, even within the framework of neglect evaluation, seems important both for diagnosis and for targeting rehabilitation of symptoms that may persist longer after the brain lesion.

In clinical practice, USN is usually assessed through the observation of the patients' behavior in performing activities of everyday life (e.g., the Catherine Bergego Scale—CBS, Bergego et al., 1995; Chen et al., 2015) and by administering psychometric tests of visuo-spatial attention, mostly performed in the peri-personal space. Among them are cancellation, line bisection, and drawing tasks. In cancellation tasks, participants must cross out target stimuli such as lines (Albert, 1973), letters (Diller & Weinberg, 1977), bells (Gauthier et al., 1989), stars (Wilson et al., 1987), and apples (Bickerton et al., 2011), in arrays of stimuli with different numbers of distractors. Line bisection requires participants to mark the perceived midpoint of a horizontal line (Fortis et al., 2010). Lastly, in drawing tasks, participants may be asked to copy an image (a single object or multiple elements) or to draw an object from memory (Bisiach & Vallar, 2000; De Renzi, 1982; Gainotti et al., 1972; Halligan & Marshall, 1993; Spinnler & Tognoni, 1987). In addition to these tasks, USN can also be assessed in representational (imaginal) space. Imaginal USN may be examined, requiring patients to recall items located on the two sides of a highly familiar place, seen "with the mind's eye" from a given vantage point. Such items may include buildings and shops, as in the "Piazza del Duomo di Milano" (Bisiach et al., 1981) or the "Piazza dei 500 in Roma" (Guariglia et al., 1993), objects in a room (Bisiach & Luzzatti, 1978; Guariglia et al., 1993), cities on a map of France (Rode et al., 1995), or Place Neuve in Geneva (Ortigue et al., 2003). This procedure requires retrieval from long-term memory of topographical and semantic information, which might, for the purpose of performing the task, be temporarily stored in a short-term visuo-spatial retention system, such as Baddeley and Lieberman's (1980) "visuo-spatial scratchpad" conceived as a mental screen on which spatial information can be represented. When patients show contralateral neglect of visuo-spatial representational space, that part of the mental screen may be inoperative, or the process of scanning it may be impaired.

While paper-and-pencil tests are widely used in clinical practice, they have some limitations. First, performance on paper-and-pencil tests does not necessarily reflect the functioning of patients in real-life conditions. Functional scales, such as the Catherine Bergego Scale, have the advantage of describing the behaviours of patients in everyday activities but suffer from the subjectivity of the examiner's judgement. Another limitation of paper-and-pencil tasks is that they assess mainly the peri-personal space component. Over the past two decades, several computerized and virtual reality (VR) tools have been developed (reviews in Giannakou et al., 2022; Ogourtsova et al., 2017; Sorita et al., 2025; Terruzzi et al., 2024). Although they offer the possibility of more controlled stimulation and measurement conditions (e.g., duration of stimulus presentation, recording of response speed, etc.) within more complex and interactive activities, VR and computerized tasks are frequently lacking proper validation and, like paper-and-pencil ones, often assess USN primarily in peri-personal space, even if attempts of VR tasks for far space evaluation are on record. Despite these potential advantages of VR and computerized tools, paper-and-pencil tests are still the most widely used in the clinical setting, because of their easy application and interpretation, presence of extensive normative validation, and low costs (Moore et al., 2022; SINP, 2024).

To detect USN, even in its mild manifestations, standardized, reliable administration, and scoring procedures are required, as indicated by the most recent Italian national clinical guidelines for neglect (SINP, 2024). Tests should have adequate psychometric properties, including a range of scores adequate to capture the presence and variety of lateralized disorders associated with the syndrome (including attentional and representational signs, perceptual and visuo-motor components), and normative data collected in the Italian population, but exportable to other culturally similar international settings, after adaptation. Yet, most commonly used paper-and-pencil tests lack recent and comprehensive normative data; indeed, besides some new recent standardization (Mancuso et al., 2015, 2019; Wilson et al., 2010), several other references are old or provide only partial normative data (e.g., Albert, 1973; De Renzi, 1982; Gainotti et al., 1972; Halligan & Marshall, 1993; Moore et al., 2022; Spinnler & Tognoni, 1987; Vallar et al., 1994). Considering population trends, particularly the increase in average age, educational, as well as visuo-spatial skills due to a more diffuse use of technological devices, there is a need to update and extend norms for different components of attentional and representational processing.

Moreover, as stated previously, considering that USN is a complex syndrome that can manifest with non-spatial attentional alterations (Robertson et al., 1995; Robertson et al., 1998), as well as associated "positive symptoms," it is important to have normed indexes and procedures assessing also these aspects, since they can indeed influence the evaluation of spatial lateralized performances (see Huygelier et al., 2020). It is also important to note that despite the clear prevalence of left USN following right hemisphere injury, the occurrence of right USN after left brain injury is not uncommon, but there are very few validated tests with normative data for this type of spatial bias (Esposito et al., 2021; Veronelli & Vallar, 2025).

In the light of these considerations, the present study aims to: (1) define a detailed set of quantitative norms and structured guidelines for the administration and scoring of an extensive number of components of left and right USN, with the use of a wide number of tests including line bisection, cancellations tasks for egocentric and allocentric USN, copy of drawings, drawings from memory; (2) develop a new test for representational neglect "the North Italy Cities test", and not only for visuo-motor components, as imaginal neglect involves a defective representation of the internally visualized space, which, as described previously, can be selectively compromised; (3) derive a comprehensive set of performance

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

indexes as well as additional parameters such as execution times, perseverations, and signs of apraxia, for a better characterization of the patients' performance; (4) provide updated, regression-based norms of defective performances of such indexes with Equivalent Scores (ES), to correctly interpret patients' results and difficulties.

The accurate assessment of multiple spatial components that may be impaired is a main clinical need to correctly diagnose USN. Evaluating only a subset of symptoms encounters the risk of underdiagnosing patients, with potential consequences in terms of functional disability. The precise identification of the impaired functions would help predict which difficulties patients may encounter in daily activities (such as navigation, reading, or using objects), and, in turn, monitor the effectiveness of rehabilitation.

Methods

Participants and sample size estimation

Two hundred and seventy healthy participants (139 females, 131 males; mean age: 60.57 ± 12.79 years, range: 40–89; mean educational level: 11.58 ± 4.65 years, range: 5–18) were recruited in Lombardy, Northern Italy. All participants took part in this study on a voluntary basis, recruited through announcements and personal referrals. Recruitment and screening of participants were conducted by trained examiners through an interview to verify the inclusion criteria. All participants were Italian speakers, native or fluent Italian speakers (i.e., resident in Italy for at least twenty years), and right-handed. They reported no neurological or major psychiatric diseases, nor any visual impairments. All had normal or corrected-to-normal vision. Medical histories were also reviewed to exclude relevant visual or medical conditions that could affect task performance. The sample was stratified into five age levels (40–49 years, 50–59 years, 60–69 years, 70–79 years, >80 years) and four schooling levels, i.e., primary school (up to 5 years of education), middle school (6–8 years), high school (8–13 years), university (>13 years) (See Table 1). The lower age limit of 40 years was chosen in order to reflect the most representative age range for stroke occurrence (Feigin et al., 2025). The study was approved by the Ethics Committee of Ethics Committee of IRCCS Istituto Auxologico Italiano (ID: 25C122). All participants provided their written informed consent. In accordance with previous normative studies (e.g., Aiello et al., 2022a, 2022b, 2022c), the minimum sample size for ES-based norms was estimated at N = 193 (G*Power 3.1.9.6; Heinrich-Heine-Universität Düsseldorf, Germany) for a multiple regression, assuming a small-to-medium effect size (f2 = 0.075), $1-\beta = 0.90$, $\alpha = 0.05$, and three predictors (i.e., the three demographic predictors: age, education, and gender). By consequence, our sample fitted perfectly and exceeded the sample size requirements for these analyses.

Materials and procedures: Neuropsychological USN tests battery

The following tests for assessing USN were administered: cancellation tasks, line bisection, drawing by copy and from memory tasks, and a new test for representational neglect.

Table 1 Sample stratification for age, education, and gender

M/F	Age				
Education	**40–49**	**50–59**	**60–69**	**70–79**	**>80**
5≤	0/0	4/4	5/9	6/8	5/5
6–8	13/8	8/12	8/5	6/9	2/3
9–13	11/13	9/15	7/11	6/6	3/2
>13	9/13	11/5	9/6	6/3	3/2

Note: Cells show male/female (M/F) ratio for each co-occurrence.

All of them were paper-and-pencil tasks, where the stimuli were printed on an A4 sheet of paper, which was placed horizontally in front of the participant, aligned to their mid-sagittal plane. The paper was always fixed on the table with adhesive tape positioned in its middle in order to hold it firmly in place. No restrictions were imposed on participants regarding their eyes and head movements. The examiner was seated in front of the participant, aligned with his/her body midline. A detailed description of the administration and scoring procedures of each task, as well as the stimuli, is reported in the Supplementary Materials. For an overview of all tests included in the battery. Moreover, some examples of scoring, to clarify how to apply the proposed scoring to the patients' errors, are also provided in the Supplementary Materials. It should be clarified that the terms "contralesional" and "ipsilesional" are used in the context of clinical application. However, since validation was conducted on healthy subjects, their interpretation should refer to the left or right side of space relative to the body midline, rather than the presence of a lesion, see Table 2.

Line bisection task

In the line bisection task, participants were asked to mark the subjective midpoint of six horizontal black lines of three different lengths (10, 15, 25 cm; all 2 mm in width; 2 items per length).

The main score was the **mean percentage deviation** from the exact half of the line, as a standardized convention (e.g., Ferber & Karnath, 2001; Fortis et al., 2010; Schenkenberg et al., 1980), calculated across all lines, with positive values indicating rightward and negative values leftward deviations. Separate norms were also derived for short, medium, and long lines (see Supplementary 1: Line Bisection).

Cancellation tasks

In the cancellation tasks, participants were asked to identify and mark all target stimuli presented on a sheet of paper, while ignoring the distractor stimuli. Each target could be marked with just one line. Three cancellation tests were administered: line cancellation, star cancellation, and the cancellation test of full geometrical items.

Line cancellation

This test is a modified version of Albert's line cancellation (Albert, 1973). Target stimuli consisted of 40 segments

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 2 Overview of all tests included in the battery

TYPE OF TASK	TYPE OF NEGLECT	TEST	SCORING INDICES
Perceptual / (visuo-motor exploration) processing task	Egocentric neglect in peripersonal space	**Line Bisection** *(Supplementary 1)*	• % Rightward Deviation (all lines, 10 cm, 15 cm, 25 cm); • % Leftward Deviation (all lines, 10 cm, 15 cm, 25 cm)
Visuo-motor exploration of spatial space task	Egocentric neglect in peripersonal space	**Line Cancellation** *(Supplementary 2.1)*	• Accuracy; • R/L Asymmetry; • Perseveration Score; • Perseveration Index; • Execution Time
		Star Cancellation *(Supplementary 2.2)*	• Accuracy; • R/L Asymmetry; • Perseveration Score; • Perseveration Index; • Execution Time
	Egocentric and allocentric neglect in peripersonal space	**Circle Cancellation** *(Supplementary 2.3)*	• Accuracy; • Egocentric R/L Asymmetry; • Allocentric R/L Asymmetry; • Perseveration Score; • Perseveration Index; • Execution Time
		Triangle Cancellation *(Supplementary 2.3)*	• Accuracy; • Egocentric R/L Asymmetry; • Allocentric R/L Asymmetry; • Perseveration Score; • Perseveration Index; • Execution Time
	Egocentric neglect in peripersonal space	**Copy of a Daisy** *(Supplementary 3.1)*	• Accuracy; • Asymmetry; • Perseveration Score; • Apraxia
		Copy of a Butterfly *(Supplementary 3.2)*	• Accuracy; • Asymmetry; • Perseveration Score; • Apraxia
		Total Simple Drawings (Daisy + Butterfly)	• Total Accuracy; • Total Perseveration Score

(continued)

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 2 Continued.

TYPE OF TASK	TYPE OF NEGLECT	TEST	SCORING INDICES
	Egocentric and allocentric neglect in peripersonal space	**Copy of 5 Elements Complex Drawing** *(Supplementary 3.3)*	• Accuracy; • Egocentric Accuracy; • Allocentric Accuracy; • R/L Asymmetry; • Perseveration Score; • Apraxia
		Copy of Two Daisies *(Supplementary 3.4)*	• Accuracy; • Egocentric Accuracy; • Allocentric Accuracy; • R/L Asymmetry; • Perseveration Score; • Apraxia
		Copy of Geometrical Figures *(Supplementary 3.5)*	• Accuracy; • Egocentric Accuracy; • Allocentric Accuracy; • R/L Asymmetry; • Perseveration Score; • Apraxia
Imagery and Visuo-motor exploration	Representational neglect and Egocentric neglect in peripersonal space	**Memory Drawing of a Daisy** *(Supplementary 4.1)*	• Accuracy; • R/L Asymmetry; • Perseveration Score
		Memory Drawing of a Butterfly *(Supplementary 4.2)*	• Accuracy; • R/L Asymmetry; • Perseveration Score
		Total Memory Drawings (Daisy + Butterfly)	• Total Accuracy; • Total Perseveration
		Clock Drawing Test *(Supplementary 5)*	• Numbers; • Hands; • Total; • R/L Asymmetry; • Perseveration
Imagery task	Representational neglect	**Northern Italy Cities Test** *(Supplementary 6)*	• Rightward Asymmetry; • Leftward Asymmetry

For each test, the table reports the corresponding task category (Vallar & Bolognini, 2014), the type of neglect assessed, and the computed scoring indices. Supplementary materials provide detailed descriptions and scoring procedures for each task. *Notes:* R = rightward; L = leftward.

pseudo-randomly distributed on a horizontally oriented A4 sheet. Lines were arranged symmetrically in four columns of 10, and no distractors were present (see Fig. S1).

Star cancellation

This test is a modified version of the star cancellation task of the Behavioural Inattention Test battery (BIT; Wilson et al., 1987; Wilson et al., 2010). Stimuli consisted of 60 smaller target stars (30 on the right and 30 on the left side) and 76 distractors (i.e., bigger stars, words, and letters) displayed on a horizontally-oriented A4 sheet (see Fig. S2).

Cancellation task of full geometrical items

This task is a modified version of that by Ota et al. (2001) that allows for discriminating between “egocentric” and “allocentric” forms of USN. It consists of two tests: circle cancellation and triangle cancellation. In the Circle Cancellation test stimuli consisted of 20 full target circles and 40 semi-circle distractors with a missing portion on either the left or right side (see Fig. S3). In the Triangle Cancellation test stimuli consisted of 20 full triangles and 40 pseudo-triangle distractors, half with missing portions on the left and half on the right (see Fig. S4).

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

From the cancellation tasks, the following scorings were derived (see Supplementary 2.1–2.4): **accuracy score** (i.e., total number of crossed-out targets), **asymmetry score** (i.e., difference between targets cancelled on the right and left sides), **perseveration score** (i.e., not-requested additional marks), **perseveration index** (i.e., ratio of perseverative marks to total targets cancelled), and **execution time** (i.e., total time, in seconds, to complete the task). In the cancellation task of full geometrical items, an additional **allocentric asymmetry score** was calculated (i.e., difference between marked distractors with left opening and those with right opening, Supplementary 2.3–2.4).

Copy drawing tasks

In these tasks, participants were asked to replicate drawings presented on a sheet of paper, in the lower part of the sheet (i.e., below the model), as accurately as possible. Four copying tasks were administered: two simple drawings (copy of a daisy and a butterfly) and three more complex figures (five-element complex drawing, two daisies, and geometrical shapes).

Copy of simple drawings

On the upper of two different A4 sheets (vertically oriented), models of a daisy and of a butterfly were presented, each one on a single sheet. The participant was asked to copy the drawing in the lower part of the sheet. The *daisy* was made up of three elements: corolla, stem, and two leaves (one on the right and the other on the left; veins were not assessed for scoring) (see Fig. S5). The *butterfly* was made up of the body, two antennas (one on the right, the other on the left of the body), and four wings (two on the right and two on the left); wings and antennas were symmetrical to the body (see Fig. S6).

From the simple drawing copy tasks the following scorings were derived (see Supplementary 3.1 & 3.2): **accuracy score** (i.e., degree to which each element was correctly copied), **asymmetry score** (i.e., difference between the accuracy in the right and in the left sides of the figure), **perseveration score** (i.e., extra or redundant lines/elements added during copying), and **constructional apraxia score** (i.e., overall quality of the copied drawing, from accurate to unrecognizable drawing). In addition, two total scores were calculated: **total simple-drawing accuracy** (i.e., sum of accuracy scores for daisy and butterfly) and **total simple-drawing perseveration** (i.e., sum of perseveration scores for daisy and butterfly).

Copy of complex drawing

Five-element complex drawing

This is a modified version of the complex drawing task of Gainotti et al. (1972). The model was presented at the top of the sheet, placed horizontally. The participant was asked to copy a figure containing five elements, drawn along a horizontal line that represents the ground. From left to right, there were two trees, a house, and two pine trees. The sheet can be divided into left and right elements; with respect to the central element, the house door and circular window belong to the left side, whereas the square window and chimney belong to the right side (see Figs. S7 and S8).

Two daisies copying

This is a modified version of the drawing task of Halligan and Marshall (1993). The participant was asked to copy a model showing two daisies in a pot presented in the upper part of a vertically oriented A4 sheet. Each daisy consisted of one corolla, one stem, and three leaves (two of which were on the right side and one on the left side of the stem) (see Figs. S9 and S10).

Geometrical shapes copying

Three aligned geometrical shapes were presented in the upper part of an A4 sheet. From left to right: (1) a circle split into four quarters by a cross, (2) a rhombus, and (3) a square (see Figs. S11 and S12).

From the complex drawing copy tasks the following scorings were derived (see Supplementary 3.3–3.5): **accuracy score** (i.e., degree to which each element was correctly copied), **egocentric, space-based accuracy score** (i.e., omissions relative to the contralesional side of the figure), **allocentric, object-based accuracy score** (i.e., omissions relative to the contralesional half of each element), **asymmetry score** (i.e., difference between omissions on the left and right sides), **perseveration score** (i.e., extra or redundant lines/elements added during copying), and **constructional apraxia score** (i.e., overall quality of each element, from accurate to unrecognizable).

Daisy and butterfly drawing from memory

In these tasks, participants were required to draw a *daisy* and a *butterfly from memory*. For each drawing, the following scores were derived (see Supplementary 4.1–4.2): **accuracy score** (i.e., degree to which each element was correctly reproduced), **asymmetry score** (i.e., difference between accuracy in the right and left sides of the figure), and **perseveration score** (i.e., extra or redundant lines/elements added during drawing). In addition, two total scores were calculated: **total memory-drawing accuracy** (i.e., sum of accuracy scores for daisy and butterfly) and **total memory-drawing perseveration** (i.e., sum of perseveration scores for daisy and butterfly).

Clock drawing task

The participant was given a pre-drawn empty circle, presented in the middle of a vertically oriented A4 sheet (See Fig. S13). The participant's task was to write all the hour numbers in the correct positions, as on a regular *clock*, and to draw the hands pointing to 11:10.

The following scorings were derived (see Supplementary 5): **accuracy score** (i.e., correctness placement of numbers and clock hands), **asymmetry score** (i.e., difference between errors in the right and left halves of the clock), and **perseveration score** (i.e., extra or redundant lines/elements added to numbers, hands, or other parts of the clock).

The North Italy cities test

In this test, the participant was asked to imagine a map of Northern Italy (including the regions: Piemonte, Valle d'Aosta, Liguria, Lombardia, Emilia-Romagna, Veneto, Trentino Alto Adige, Friuli Venezia Giulia) divided into two equal parts by the city of Brescia, which was represented in the middle of the map (see Fig. S14 and Fig. S15). The

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

participant was required to recall all the cities located on the right and left sides of this division. One minute was given for recalling the cities on each side.

The following scorings were derived (see Supplementary 6): the **total number of cities** recalled on the right and left sides, and the **asymmetry score** (i.e., difference between the number of cities listed on the right and left sides).

Analyses

Normative values to define the defective cut-offs for spatial (right side- or left-side biases), perseverative, or constructional deficits were derived by means of the ES method, a normalized 4-level scale system (ranging from 0 to 4 points) largely employed in Italian standardization studies, which allow deriving cut-off scores in terms of equivalent points that facilitate the interpretation of patients' performance and allow to compare scores across tasks with different scores range (Aiello & Depaoli, 2022; Capitani & Laiacona, 2017; del Cacho-Tena et al., 2024; Spinnler & Tognoni, 1987). First, a stepwise regression is calculated to adjust raw scores for significant demographic predictors among age, education, gender, and their transformations. Stepwise regression was used to select relevant demographic predictors. While this approach may increase the risk of Type I error and yield unstable models, and no additional sensitivity analyses were performed, its application is consistent with previous regression-based normative studies (e.g., Bolognini et al., 2022; Hubbard et al., 2008; Lannoo & Vingerhoets, 1997). To enhance transparency, we have added model fit statistics and confidence intervals for all coefficients in Table S2. When necessary, transformed demographic variables (e.g., logarithmic, inverse or cubic) were employed to identify the strongest association between predictors and raw scores (Aiello & Depaoli, 2022; del Cacho-Tena et al., 2024). This follows the standard practice in regression-based normative studies for neuropsychological testing, where scores often have skewed distributions and non-linear relationships with demographic factors (e.g. Aiello et al., 2022a; Fortis et al., 2010; Laiacona et al., 2000). Subsequently, outer and inner tolerance limits (oTL; iTL) were identified on ranked adjusted scores (ASs) to provide a non-parametric, interval estimate of cut-off values. ASs≤oTL are attributed an ES = 0, i.e., an "impaired" performance, whereas ASs≥Mdn have an ES = 4, i.e., a "high-end normal" performance (>50th percentile). ASs included between the oTL and the Mdn are subdivided into three further ability levels, whose thresholds are identified via a z-score-based approach: ES = 1 (i.e., "borderline"), ES = 2 (i.e., low-end normal performance), ES = 3 (i.e., normal performance). ASs falling between the oTL and the iTL fall under the ES = 1 but cannot be considered either below or above the cut-off.

For the asymmetry scores (including the performance on the line bisection test), norms for both leftward and rightward asymmetries are provided.

All analyses were carried out with jamovi 2.5 (the jamovi project, 2024), and R Statistical Software 4.1.2 (R Core Team, 2021) within the R-Studio environment (RStudio Team, 2020). The significance level was set at $\alpha = 0.05$. Following the common practice in neuropsychological normative studies (Spinnler & Tognoni, 1987), no correction for multiple comparisons was applied.

Results

Descriptive statistics of raw scores (means, medians, standard deviations, and ranges) are provided in Table S1. Adjustment equations for raw scores are reported in Table 3, whereas derived cut-off values, outer and inner tolerance limits, as well as ES can be found in Table 4. When no effect of age, education, or gender was observed, the corresponding adjustment equation is not provided, and the cut-off based on the raw score should be considered. A calculation sheet with implemented adjustment equations is provided in the Supplementary Material.

Several scores were predicted by different transformations of age (all $Ps < .048$) and education (all $Ps < .038$). In particular, age influenced performance in cancellation tasks (i.e., older participants have slightly lower accuracy and longer execution times), copy drawing (i.e., older participants show more perseverations), memory and clock drawing tasks (older participants have reduced accuracy), and in the asymmetry score of the North Italy Cities test. Education influenced execution time in cancellation tasks and apraxia scores in copy drawing tasks, but also accuracy scores in memory and clock drawing tasks. Finally, gender only influenced deviations in the line bisection bias (females showed greater leftward deviations; $P < .001$), and the accuracy in drawing a butterfly from memory (females were overall more accurate than males; $P < .005$).

For scores where performance was close to the ceiling or floor levels for most participants (e.g., asymmetry indices and perseveration scores in cancellation and drawing tasks; see Table 4 for the full report), the score range was insufficient to calculate the full range of ESs; therefore, for these parameters, the outer tolerance limit is provided as a cut-off value.

Discussion

In the present study, we developed regression-based norms for the Italian population for the most widely used paper-and-pencil tests for USN assessment. These tests are largely employed in clinical practice because of their ease of use, low cost, and a well-established diagnostic utility (Moore et al., 2022; SINP, 2024). Among them are measures for both egocentric and allocentric neglect, including line bisection, cancellation (lines, stars, and full geometrical items), copying tasks (from simple drawings, such as a daisy and a butterfly, to more complex ones like five-element, two daisies, and geometrical shapes), drawing from memory (daisy and butterfly tasks), representational drawing (clock drawing test) and a new test for representational neglect, the North Italy Cities test. The battery is primarily designed for experts in neuropsychological assessment; it can also be employed by other professionals after adequate training and following the guidelines provided.

Having updated, population-specific normative data with adequate psychometric properties is essential to improve the accuracy of USN diagnosis and better capture the variety of associated impairments (Aiello et al., 2022d; SINP, 2024).

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 3 Adjustment equations

Test	Index	AS equation
Line Bisection	All lines: % Deviation	RS + 1.417312*[(gender)-0.5148148)]
	10-cm lines: % Deviation	RS + 1.236515*[(gender) -0.5148148)]
	15-cm lines: % Deviation	RS + 1.599813*[(gender) -0.5148148)]
	25-cm lines: % Deviation	RS + 1.415608*[(gender) -0.5148148)]
Line Cancellation	Accuracy	RS-0.099409*[ln(100-age)-3.611272)]
	Asymmetry	RS + 0.075527*[ln(edu)-2.357039)]
	Perseveration Score	RS-1.025498*[(1/edu)-0.105054]
	Perseveration Index	*No adjustment*
	Execution Time	RS-0.387157*(age-60.57037)-38.45276*[(1/edu)-0.105054]
Star Cancellation	Accuracy	RS + 0.000002*[(age^3)- 252296.97037]
	Asymmetry	*No adjustment*
	Perseveration Score	RS-2.230893*[(1/edu)-0.105054]
	Perseveration Index	RS-0.03732*[(1/edu)-0.105054]
	Execution Time	RS-0.000073*[(age^3)-252296.97037)-94.87775*[(1/edu)-0.105054]
Circle Cancellation	Accuracy	*No adjustment*
	Egocentric Asymmetry	*No adjustment*
	Allocentric Asymmetry	RS + 0.273726*[ln(100-age)-3.611272)]
	Perseveration Score	*No adjustment*
	Perseveration Index	*No adjustment*
	Execution Time	RS + 15.20439*[ln(100-age)-3.611272)-27.13393*[(1/edu)-0.105054]
Triangle Cancellation	Accuracy	*No adjustment*
	Egocentric Asymmetry	*No adjustment*
	Allocentric Asymmetry	RS + 5.943978*[(1/age)- 0.017275]
	Perseveration Score	*No adjustment*
	Perseveration Index	*No adjustment*
	Execution Time	RS + 15.64932*[ln(100-age)-3.611272)-26.52381*[(1/edu)-0.105054]
Copy of a daisy	Accuracy	*No adjustment*
	Asymmetry	*No adjustment*
	Perseveration Score	RS-0.000001*[(age^3)- 252296.97037]
	Apraxia	RS-0.076697*[ln(100-age)- 3.611272]
Copy of a butterfly	Accuracy	*No adjustment*
	Asymmetry	*No adjustment*
	Perseveration Score	RS + 0.375044*[ln(100-age)- 3.611272]
	Apraxia	RS + 1.165346*[(1/edu)- 0.105054]
Total score simple drawings (daisy and butterfly)	Total Accuracy	*No adjustment*
	Total Perseveration score	RS-0.000002*[(age^3)- 252296.97037)]
Copy of 5 Elements complex drawing	Accuracy	*No adjustment*
	Egocentric Accuracy	*No adjustment*
	Allocentric Accuracy	*No adjustment*
	Asymmetry	RS-0.79133*[(1/edu)-0.105054]
	Perseveration Score	*No adjustment*
	Apraxia	RS + 0.000098*[(age^2)-3831.82963] + 7.35392*[(1/edu)-0.105054]

(continued)

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 3 Continued.

Test	Index	AS equation
Copy of two daisies	Accuracy	*No adjustment*
	Egocentric Accuracy	*No adjustment*
	Allocentric Accuracy	*No adjustment*
	Asymmetry	*No adjustment*
	Perseveration Score	RS + 17.8681*[(1/age)- 0.017275]
	Apraxia	RS + 1.405891*[(1/edu)- 0.105054]
Copy of geometrical figures	Accuracy	*No adjustment*
	Egocentric Accuracy	*No adjustment*
	Allocentric Accuracy	*No adjustment*
	Asymmetry	*No adjustment*
	Perseveration Score	AS = RS + 0.146203*[ln(100-age)- 3.611272]
	Apraxia	AS = RS-0.233113*[ln(100-age)- 3.611272) + 1.233568*[(1/edu)-0.105054]
Memory drawing of a daisy	Accuracy	*No adjustment*
	Asymmetry	*No adjustment*
	Perseveration Score	*No adjustment*
Memory drawing of a butterfly	Accuracy	RS-0.275256*[ln(100-age)- 3.611272) + 3.01753*[(1/edu)-0.105054]- 0.174358*(gender-0.5148148)]
	Asymmetry	*No adjustment*
	Perseveration Score	*No adjustment*
Total score of memory drawings (daisy + butterfly)	Total Accuracy	RS-0.249975*[ln(100-age)- 3.611272) + 3.850206*[(1/edu)-0.105054]- 0.226216*(gender-0.5148148)]
	Total Perseveration Score	*No adjustment*
Clock Drawing	Numbers	RS + 0.000096*[(age^2)- 3831.82963) + 4.539185*[(1/edu)-0.105054]
	Hands	RS + 0.133469*[sqrt(age)- 7.739267) + 2.470652*[(1/edu)-0.105054]
	Total Accuracy	RS + 0.020094*(age- 60.57037) + 6.894949*[(1/edu)-0.105054]
	Asymmetry	*No adjustment*
	Perseveration score	*No adjustment*
North Italy Cities	Asymmetry	AS = RS-0.000223*[(age^2)- 3831.82963]

Notes: “Gender” was coded as 0 = male, 1 = female. AS = Adjusted Score; RS = Raw Score.

In line with previous standardization studies, our results confirm that factors such as age, education, and gender significantly influence test performance and should be considered when defining cut-off scores (Spinnler & Tognoni, 1987). These demographic effects, while sometimes limited in magnitude (e.g., gender), contribute to the regression-based normative equations and to the adjustment of raw scores, thereby improving clinical interpretation at the individual level.

As for the representativeness and generalizability of the battery, although participants were recruited in Lombardy, the sample covered a wide range of socio-educational levels and included individuals from both urban and rural areas, supporting its representativeness at least for the Italian population. Notably, visuo-spatial performance has been shown not to substantially differ across Italian regions (e.g., Aiello et al., 2022b; Dapor et al., 2025). Moreover, most NeBa indices are based on non-linguistic visuo-spatial functions with low cultural demands and are therefore likely transferable to other socio-culturally comparable contexts, in line with previous studies that have successfully used visuo-spatial batteries or norms developed for one country in a different one (e.g., BIT, line bisection tasks). An exception is the North Italy Cities representational task, which is intrinsically geographically specific, similar to other tasks for representational neglect (e.g., Map of France, Place Neuve).

When comparing our results with existing available normative data, we identified both similarities and differences. For example, in the line bisection task, we found a gender effect that was not reported in the Batterie d’Évaluation de la Négligence Spatiale (BEN) (Azouvi et al., 2002), but

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 4 Tolerance limits and Equivalent Scores

Test	Index	oTL	iTL	ES = 0	ES = 1	ES = 2	ES = 3	ES = 4
Line Bisection –All lines	Rightward % Deviation	4.44	2.8	≥ 4.44	4.43–2.32	2.31–0.6	0.59 – −0.89	< −0.89
	Leftward % Deviation	−6.67	−5.45	≤ −6.67	−6.66 – −5.05	−5.04 – −3.09	−3.08 – −0.93	> − 0.93
10-cm lines	Rightward % Deviation	8.60	4.60	≥8.60	8.59–3.60	3.59–1.36	1.35 —1.14	< − 1.14
	Leftward % Deviation	−9.40	−6.40	≤ −9.40	−9.39 – −5.40	−5.39 —2.64	−2.63 —0.40	> −0.40
15-cm lines	Rightward % Deviation	6.78	4.11	≥6.78	6.77–2.78	2.77–0.78	0.77 —1.49	< − 1.49
	Leftward % Deviation	−8.56	−5.89	≤ −8.56	−8.55 —5.22	−5.21 —3.22	−3.21 - - 1.16	> −1.16
25-cm lines	Rightward % Deviation	5.67	3.09	≥ 5.67	5.66–2.29	2.28–0.29	0.28 —1.53	< −1.53
	Leftward % Deviation	−8.73	−6.51	≤ −8.73	−8.72 – −5.93	−5.92 —3.53	−3.52 —1.13	> −1.13
Line Cancellation	Accuracy	39.02	39.95	≤ 39.02	39.03–39.95	39.96–39.97	39.98–39.99	> 39.99
	Rightward Asymmetry	0.98		≥ 0.98				
	Leftward Asymmetry	−0.96		≤ −0.96				
	Perseveration Score	1.05		≥ 1.05				
	Perseveration Index	1.05		≥ 1.05				
	Execution Time	53.53	42.41	≥ 53.53	53.52–39.34	39.33–32.46	32.45–26.88	< 26.88
Star Cancellation	Accuracy	55.15	56.95	≤ 55.15	55.16–57.44	57.45–58.70	58.71–59.64	> 59.64
	Rightward Asymmetry	3		≥ 3				
	Leftward Asymmetry	−4		≤ −4				
	Perseveration Score	2.11		≥ 2.11				
	Perseveration Index	1.03		≥ 1.03				
	Execution Time	83.94	68.99	≥ 83.94	83.93–66.12	66.11–56.9	56.89–46.44	< 46.44
Circle Cancellation	Accuracy	17		≤ 17				
	Rightward Egocentric Asymmetry	2		≥ 2				
	Leftward Egocentric Asymmetry	−2		≤ −2				
	Rightward Allocentric Asymmetry	1.01	0.12	≥ 1.01	1–0.11	0.10–0.08	0.07–0.02	<0.02
	Leftward Allocentric Asymmetry	−0.23	−0.14	≤ − 0.23	−0.22 – −0.13	−0.12 – −0.05	−0.04 – −0.03	> − 0.03
	Perseveration Score	1		≥ 1				
	Perseveration Index	1.05		≥ 1.05				
	Execution Time	52.92	43.73	≥ 52.92	52.91–41.22	41.21–33.92	33.91–28.92	< 28.92

(continued)

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 4 Continued.

Test	Index	oTL	iTL	ES = 0	ES = 1	ES = 2	ES = 3	ES = 4
Triangle Cancellation	Accuracy	16		≤ 16				
	Rightward Egocentric Asymmetry	2		≥ 2				
	Leftward Egocentric Asymmetry	−3		≤ −3				
	Rightward Allocentric Asymmetry	0.05		≥ 0.05				
	Leftward Allocentric Asymmetry	−0.04		≤ −0.04				
	Perseveration Score	1		≥ 1				
	Perseveration Index	1.05		≥ 1.05				
	Execution Time	52.85	46.73	≥ 52.85	52.84–44.30	44.29–35.66	35.65–29.94	<29.94
Copy of a daisy	Accuracy	1.5		≤ 1.5				
	Asymmetry	|0.5|		|0.5|				
	Perseveration Score	1.81	1.1	≥ 1.81	1.80–0.97	0.96–0.16	0.15–0.08	<0.08
	Apraxia	1.01		≤ 1.01				
Copy of a butterfly	Accuracy	1.5		≤ 1.5				
	Asymmetry	|0.5|		|0.5|				
	Perseveration Score	1.97	1.10	≥ 1.97	1.96–0.96	0.95–0.15	0.14–0.07	<0.07
	Apraxia	1.02		≤ 1.02				
Total simple drawings (daisy + butterfly)	Total Accuracy	3		≤ 3				
	Total Perseveration Score	3.48	2.14	≥ 3.48	3.47–1.36	1.35–0.35	0.34 –0.21	<0.21
Copy of 5 Elements complex drawing	Accuracy	9.5		≤ 9.5				
	Egocentric Accuracy	9.5		≤ 9.5				
	Allocentric Accuracy	9.5		≤ 9.5				
	Rightward Asymmetry	0.92		≥ 0.92				
	Leftward Asymmetry	−1.08		≤ −1.08				
	Perseveration Score	3		≥ 3				
	Apraxia	7.61	8	≤ 7.61	7.62–8.70	8.71–9.56	9.57–9.73	> 9.73

(continued)

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Table 4 Continued.

Test	Index	oTL	iTL	ES = 0	ES = 1	ES = 2	ES = 3	ES = 4
Copy of two daisies	Accuracy	3		≤ 3				
	Egocentric Accuracy	3.5		≤ 3.5				
	Allocentric Accuracy	3		≤ 3				
	Asymmetry	|1|		|1|				
	Perseveration Score	1.96	1.06	≥ 1.96	1.95–1	0.99–0.12	0.11–0.03	<0.03
	Apraxia	2.96		≤ 2.96				
Copy of geometrical figures	Accuracy	5.5		≤ 5.5				
	Egocentric Accuracy	5.5		≤ 5.5				
	Allocentric Accuracy	5.5		≤ 5.5				
	Asymmetry	|0.5|		|0.5|				
	Perseveration Score	1.03		≥ 1.03				
	Apraxia	4.86	5.11	≤ 4.86	4.87–5.19	5.20–5.88	5.89–5.94	> 5.94
Memory drawing of a daisy	Accuracy	1.5		≤ 1.5				
	Asymmetry	|0.5|		|0.5|				
	Perseveration Score	3		≥ 3				
Memory drawing of a butterfly	Accuracy	0.19	0.6	≤ 0.19	0.2–1.65	1.66–1.80	1.81–1.92	> 1.92
	Asymmetry	|1|		|1|				
	Perseveration Score	1		≥ 1				
Total memory drawings (daisy + butterfly)	Total Accuracy	1.98	2.53	≤1.98	1.99–2.76	2.77–3.72	3.73–3.91	> 3.91
	Total Perseveration	3		≥ 3				
Clock Drawing Task	Numbers	9.21	10.9	≤ 9.21	9.22–11.52	11.53–11.70	11.71–11.83	> 11.83
	Hands	2.98	3.41	≤ 2.98	2.99–3.92	3.93–4.78	4.79–4.90	> 4.90
	Total	13.09	14.84	≤ 13.09	13.10–15.47	15.48–16.38	16.39–16.71	> 16.71
	Asymmetry	|1|		|1|				
	Perseveration	3		≥ 3				
Northern Italy Cities Test	Rightward Asymmetry	3.23	1.97	≥ 3.23	3.22–1.42	1.41–0.05	0.04 – −1.21	< −1.21
	Leftward Asymmetry	−6.73	−5.50	≤ −6.73	−6.72 – −4.80	−4.79 – −2.91	−2.90 – −1.03	> −1.03

Notes: oTL = outer tolerance limit; iTL = inner tolerance limit; ES = Equivalent Score; absolute values (e.g., asymmetry index) indicate that spatial cut-offs were applied in both directions, with "≥" indicating rightward and "≤" indicating leftward deviations.

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

the cut-off values are not directly comparable, due to differences in line lengths (5 cm and 20 cm). Instead, our results (oTL $\geq$ 4.44% and ≤ -6.67%) differ slightly from those previously reported in Italian samples (see Fortis et al., 2010: >5.75% and < −8.17%), potentially increasing test sensitivity for detecting mild forms of USN. In addition, we also provide separate norms for different line lengths. Indeed, neglect-related difficulties may change depending on the lines' length, with mild forms of neglect sometimes emerging only when longer lines are presented (Vallar & Ronchi, 2022). Indeed, a length effect has been found in neglect patients, in other USN assessment tasks as well, such as the Brentano Illusion Test, where different line lengths lead to distinct biases in participants' performance (Facchin et al., 2021). Moreover, in patients with USN, shorter lines may induce the well-known cross-over effect (Doricchi et al., 2005), thus mitigating the spatial bias for longer lines. Therefore, if all line lengths are averaged together, the lateralized attention effect may be less detectable, thus masking minor signs of the disorder. Having different values is then useful for a more precise evaluation. For the cancellation tasks, despite differences in the number of stimuli, our cut-offs align with previous ones from the Italian version of the BIT (see accuracy and asymmetry scores in lines and stars tasks: Wilson et al., 2010). However, at variance with the BIT, which does not distinguish between rightward and leftward omissions (a score > 3 is defective in all participants), we obtained a different threshold for leftward omissions (≤ -4). When comparing our geometrical item cancellation task with the Apple Cancellation Test, standardized by Mancuso et al. (2015) on an Italian sample, which showed no significant effects of gender, age or education on accuracy or asymmetry scores in either egocentric or allocentric space, we found an age effect on allocentric asymmetry—consistent with the original standardization by Bickerton et al. (2011). Moreover, although direct comparisons of cut-off values are not possible due to differences in stimuli, we also found significant effects of age and education on execution time.

Importantly, given the multifactorial nature of USN and its frequently associated non-lateralized deficits, we have integrated the classic horizontal asymmetry scores (calculated for rightward and leftward deviations) with measures assessing non-spatial attentional dysfunctions and "positive symptoms," such as execution times, perseverations, and constructional apraxia measures, which are frequently observed in brain-damaged populations, including USN patients.

USN patients typically show ideomotor slowing, not only due to spatial selective attention deficits but also because of broader non-lateralized attentional impairments. Indeed, individuals with USN show attentional deficits even in the ipsilesional hemispace (Husain et al., 1997; Husain & Rorden, 2003; Robertson, 2001; Robertson et al., 1995), including prolonged attentional blink (Husain et al., 1997), impaired sustained attention over time (Duncan et al., 1999; Robertson et al., 1995), and deficits in trans-saccadic spatial working memory, where patients fail to remember previously inspected locations (Husain et al., 2001; Malhotra et al., 2005). These attentional deficits may interact with the spatial attention deficits, further increasing the severity of the neglect syndrome (Bartolomeo & Chokron, 2002; Husain & Rorden, 2003). Measuring test execution time thus provides an additional indicator of the spatial exploration impairments, beyond the lateralized omission deficits, because slower or inconsistent responses may reflect the influence of these non-lateralized attentional impairments on task performance. Furthermore, having unlimited time for task execution may allow patients to possibly compensate for their deficits, potentially leading to the underestimation of the severity. On the other hand, setting time constraints may bring about difficulties in search strategies and attentional allocation that could not be visible with accuracy-based measures alone, providing a more comprehensive evaluation of USN. Even if the proposed tests have been administered without time limits in healthy participants, a cut-off for maximum time of exploration allows clinicians to provide time constraints during neuropsychological assessments.

In addition to execution time, perseveration errors were also considered, both in cancellation and drawing tasks. The term "perseveration" refers to productive aspects of the performance, ranging from the simple repetition of a previously marked target to the addition of extra targets that are subsequently crossed out, or to the inclusion of unrelated productions (e.g., the participant's signature or grass under the daisies drawings) (Ronchi et al., 2009, 2012; Rusconi et al., 2002). The present cancellation tasks allow deriving a perseveration score and a perseveration index. The perseveration score quantifies the absolute number and complexity of errors, giving more weight to complex and freely added elements (e.g., the signature). On the other hand, the perseveration index assesses the "density" of perseverative behaviors on the portion of the space explored, considering only extra marks added in the target areas. These measures capture different aspects of perseveration and allow a more precise evaluation of neglect: whereas the perseveration score is more related to qualitative differences in error types, the perseveration index focuses on the concentration of errors relative to accurate performance. Within the same logic, a perseveration score has been computed for drawing tasks, where previous evidence in neurological patients has shown that test requests that are more complex and less constrained can elicit more complex and perseverative productions (Ronchi et al., 2009).

The present normative data also extend to the assessment of constructional apraxia, a heterogeneous set of deficits with different manifestations depending on the side of the lesioned hemisphere (Gainotti & Trojano, 2018). Recent evidence (Song et al., 2025) shows that in stroke patients, signs of constructional apraxia may be overlooked in the acute post-stroke phases, being masked by the more pronounced spatial biases of USN. Therefore, constructional apraxia may be underdiagnosed in USN patients, and novel and more sensitive methods for its detection are necessary for an early diagnosis.

In addition to these new indices, we also calculated normative data for both rightward and leftward deviations, so as to render tests sensitive also to right-sided USN. Indeed, right-side USN has received relatively little attention, as most research has focused on left-sided neglect due to its higher reported prevalence. However, there is wide variability regarding neglect prevalence, which may be due to the

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

sensitivity of the tests used to assess the disorder (Bowen et al., 1999; Esposito et al., 2021). Only a small number of normative studies have addressed both directions (e.g., some subtests of the BEN battery), but we believe that this approach is essential: right-side neglect tends to be diagnosed more frequently in clinical practice when specifically assessed, highlighting the importance of appropriate diagnostic tools. Moreover, cut-off values for the rightward deviation bias, featuring the performance of patients with right hemisphere injury, cannot be directly used to classify the opposite leftward bias in the case of right-sided neglect. Indeed, our results, as well as literature concerning spatial processing in healthy participants (Bowers & Heilman, 1980; Jewell & McCourt, 2000) and spatial bias in patients (Azouvi et al., 2002), show that scores may change significantly depending on the direction (e.g., in the line bisection test the oTL is 4.44 for rightward and − 6.67 for leftward deviation, or, in the North Italy Cities test the oTL is 3.23 for rightward and −6.73 for leftward asymmetry). These differences underscore the importance of having different normative values to accurately detect and classify both left- and right-sided USN.

Finally, we introduced a new test assessing pure representational neglect, excluding the influence of motor components typically present in drawing from memory tests. Drawing inspiration from the map of France test (Rode et al., 1995, 2007), we developed the North Italy cities test, which focuses on the mental representation of familiar geographical space, without requiring any drawing or motor output. One limitation of the present task must be considered, namely, the focus on northern Italian cities, to which not every participant might be familiar. Further validation studies are needed to assess its broader applicability.

Regarding the limitations of this study and future directions, some aspects should be noted. First, a formal screening of visual disorders was not conducted in our sample; however, the participants' self-reported medical history excludes the presence of visual impairments that could potentially compromise task performance, and the examiner's monitoring of participants' performance during the testing also excludes the possibility that they suffered from visual impairments relevant to the present data collection. Another apparent limitation of the present standardization is that, since normative data were collected on a healthy population, some scores resulted in ceiling effects (e.g., asymmetry and perseveration scores). This may reduce sensitivity in detecting very mild USN forms. However, the relatively broad score ranges and the inclusion of different tests with multiple subscores in our battery help to preserve the recognition of subtle deficits. To detect suspected mild neglect forms, the administration of more demanding cancellation, drawing, and computer-based tests (e.g., with many stimuli, distractors, and complex visual search paradigms), more sensitive to small lateralized attentional deficits (Esposito et al., 2021), is recommended (Vallar & Bolognini, 2014). In addition to these considerations, while it provides extensive normative data, standardized administration guidelines, and automated scoring tools, with reference to worldwide used tests for some USN symptoms, future studies are needed for their cross-cultural adaptation; for this reason, we also provided detailed Supplementary Materials in English. Moreover, of interest will be the development of novel composite indices (e.g., integrating accuracy, execution time, and asymmetry scoring) to further refine the characterization of spatial and non-spatial attentional deficits.

Despite this, the NeBa battery offers an important contribution to current clinical practice, providing updated normative data in healthy individuals, with novel scoring methods, and offering administration guidelines along with automated scoring tools. This improves the psychometric assessment of visuo-spatial deficits, allowing for the capture of multiple components of USN impairments useful for improving neuropsychological diagnosis and for guiding the rehabilitation plan. For example, excessive performance slowness may indicate the need for intervention to improve attention, high perseveration scores can suggest opting for inhibitory-control and switching exercises with reduced distractors, and higher allocentric neglect scores may lead to adopting object-centered strategies alongside global scanning strategies.

Overall, the present study offers a complete and well-validated USN assessment battery with updated norms in a large sample of Italian participants. Based on the multivarious nature of USN, and the presence of multiple components which can be selectively affected (Saj et al., 2018; Vallar & Ronchi, 2022; Verdon et al., 2010), we suggest the following guidelines to be adopted in clinical practice, with a minimal assessment that should include the following tasks: line bisection, one or two cancellation tasks (if only one test, a test assessing ego- and allo- centric components should be used), one complex element drawing, one drawing from memory and, if administrable given the cultural constraints, the pure representational task. Finally, to facilitate its adoption in clinical practice, and possibly its translation and use in other countries, we have provided detailed guidelines for test administration and scoring in the Supplementary Materials.

Supplementary material

Supplementary material - which includes instructions for administering and scoring the NeBa, including stimuli and protocols for each test is available at *Archives of Clinical Neuropsychology* online.

Funding

This work was supported by the Italian Ministry of Health - Ricerca Corrente to N.B.

Conflict of interest

The Authors declare that there is no conflict of interest.

Author contributions

Francesca Crespi (Conceptualization, Formal Analysis, Methodology, Writing—original draft), Irene Rossi (Investigation, Methodology, Writing—review & editing), Lorenzo Diana (Formal Analysis, Methodology, Writing—review & editing), Paola Fortis (Conceptualization, Investigation, Methodology, Writing—review & editing), Giuseppe Vallar

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

(Conceptualization, Methodology, Supervision, Writing—review & editing), Nadia Bolognini (Conceptualization, Data curation, Funding acquisition, Project administration, Resources, Supervision, Writing—review & editing), and Roberta Ronchi (Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing—original draft)

Data availability statement

The data and materials supporting the findings of this study are publicly available on OSF; the dataset contains only age, gender and education level, with no personally identifying details. (https://osf.io/auc8h/).

References

Aiello, E. N., & Depaoli, E. G. (2022). Norms and standardizations in neuropsychology via equivalent scores: Software solutions and practical guides. *Neurological Sciences*, 43(2), 961–966. https://doi.org/10.1007/s10072-021-05374-0

Aiello, E. N., Esposito, A., Gramegna, C., Gazzaniga, V., Zago, S., Difonzo, T., et al. (2022a). The frontal assessment battery (FAB) and its sub-scales: Validation and updated normative data in an Italian population sample. *Neurological Sciences*, 43(2), 979–984. https://doi.org/10.1007/s10072-021-05392-y

Aiello, E. N., Gramegna, C., Esposito, A., Gazzaniga, V., Zago, S., Difonzo, T., et al. (2022b). The Montreal cognitive assessment (MoCA): Updated norms and psychometric insights into adaptive testing from healthy individuals in northern Italy. *Aging Clinical and Experimental Research*, 34(2), 375–382. https://doi.org/10.1007/s40520-021-01943-7

Aiello, E. N., Pucci, V., Diana, L., Niang, A., Preti, A. N., Delli Ponti, A., et al. (2022d). Telephone-based frontal assessment battery (t-FAB): Standardization for the Italian population and clinical usability in neurological diseases. *Aging Clinical and Experimental Research*, 34(7), 1635–1644. https://doi.org/10.1007/s40520-022-02155-3

Aiello, E. N., Rimoldi, S., Bolognini, N., Appollonio, I., & Arcara, G. (2022c). Psychometrics and diagnostics of Italian cognitive screening tests: A systematic review. *Neurological sciences: official journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, 43(2), 821–845. https://doi.org/10.1007/s10072-021-05683-4

Albert, M. L. (1973). A simple test of visual neglect. *Neurology*, 23(6), 658–664.

Anderson, B. (1993). Spared awareness for the left side of internal visual images in patients with left-sided extrapersonal neglect. *Neurology*, 43(1), 213–216. https://doi.org/10.1212/WNL.43.1_Part_1.213

Azouvi, P., Samuel, C., Louis-Dreyfus, A., Bernati, T., Bartolomeo, P., Beis, J. M., et al. (2002). Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke. *Journal of Neurology, Neurosurgery, and Psychiatry*, 73(2), 160–166. https://doi.org/10.1136/jnnp.73.2.160

Baddeley, A. D., & Lieberman, K. (1980). Spatial working memory. In Nickerson, R. S. (Ed.), *Attention and performance VIII* (pp. 521–539). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bartolomeo, P., & Chokron, S. (2002). Orienting of attention in left unilateral neglect. *Neuroscience and Biobehavioral Reviews*, 26(2), 217–234. https://doi.org/10.1016/s0149-7634(01)00065-3

Bergego, C., Azouvi, P., Samuel, C., Marchal, F., Louis–Dreyfus, A., Jokic, C., et al. (1995). Validation d'une échelle d'évaluation fonctionnelle de l'héminégligence dans la vie quotidienne: L'échelle CB [functional consequences of unilateral neglect: Validation of an evaluation scale, the CB scale]. *Annales de Readaptation et de Medecine Physique*, 38, 183–189. https://doi.org/10.1016/0168-6054(96)89317-2

Bickerton, W. L., Samson, D., Williamson, J., & Humphreys, G. W. (2011). Separating forms of neglect using the apple test: Validation and functional predicting in chronic and acute stroke. *Neuropsychology*, 25(5), 567–580. https://doi.org/10.1037/a0023501

Bisiach, E., Capitani, E., Luzzatti, C., & Perani, D. (1981). Brain and conscious representation of outside reality. *Neuropsychologia*, 19(4), 543–551. https://doi.org/10.1016/0028-3932(81)90020-8

Bisiach, E., & Luzzatti, C. (1978). Unilateral neglect of representational space. *Cortex*, 14(1), 129–133. https://doi.org/10.1016/s0010-9452(78)80016-1

Bisiach, E., & Vallar, G. (2000). Unilateral neglect in humans. In Boller, F., Grafman, J., & Rizzolatti, G. (Eds.), *Handbook of neuropsychology: Sect 1: Introduction, sect 2: Attention* (2nd ed., pp. 459–502). Amsterdam, The Netherlands: Elsevier Science Publishers B.V.

Bolognini, N., Gramegna, C., Esposito, A., Aiello, E. N., Difonzo, T., & Zago, S. (2022). The testamentary capacity assessment tool (TCAT): Validation and normative data. *Neurological Sciences*, 43(4), 2831–2838. https://doi.org/10.1007/s10072-021-05736-8

Bowen, A., McKenna, K., & Tallis, R. C. (1999). Reasons for variability in the reported rate of occurrence of unilateral spatial neglect after stroke. *Stroke*, 30(6), 1196–1202. https://doi.org/10.1161/01.str.30.6.1196

Bowers, D., & Heilman, K. M. (1980). Pseudoneglect: Effects of hemispace on a tactile line bisection task. *Neuropsychologia*, 18(4–5), 491–498.

del Cacho-Tena, A., Christ, B. R., Arango-Lasprilla, J. C., Perrin, P. B., Rivera, D., & Olabarrieta-Landa, L. (2024). Normative data estimation in neuropsychological tests: A systematic review. *Archives of Clinical Neuropsychology*, 39(3), 383–398. https://doi.org/10.1093/arclin/acad084

Capitani, E., & Laiacona, M. (2017). Outer and inner tolerance limits: Their usefulness for the construction of norms and the standardization of neuropsychological tests. *The Clinical Neuropsychologist*, 31(6–7), 1219–1230. https://doi.org/10.1080/13854046.2017.1334830

Capitani, E., Neppi-Mòdona, M., & Bisiach, E. (2000). Verbal-response and manual-response versions of the milner landmark task: normative data. *Cortex*, 36(4), 593–600. https://doi.org/10.1016/s0010-9452(08)70540-9

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Chen, P., Chen, C. C., Hreha, K., Goedert, K. M., & Barrett, A. M. (2015). Kessler Foundation neglect assessment process uniquely measures spatial neglect during activities of daily living. *Archives of Physical Medicine and Rehabilitation*, 96(5), 869–876.e1. https://doi.org/10.1016/j.apmr.2014.10.023

Corbetta, M., & Shulman, G. L. (2011). Spatial neglect and attention networks. *Annual Review of Neuroscience*, 34, 569–599. https://doi.org/10.1146/annurev-neuro-061010-113731

Coslett, H. B., Bowers, D., Fitzpatrick, E., Haws, B., & Heilman, K. M. (1990). Directional hypokinesia and hemispatial inattention in neglect. *Brain*, 113(2), 475–486. https://doi.org/10.1093/brain/113.2.475

Coslett, H. B. (1997). Neglect in vision and visual imagery: A double dissociation. *Brain*, 120 (Pt 7)(7), 1163–1171. https://doi.org/10.1093/brain/120.7.1163

Dapor, C., Devita, M., Iannizzi, P., Arbia, E., Bruzzano, A., Dessì, M., et al. (2025). The Montreal cognitive assessment (MoCA) 8.1 version, including the memory index score (MoCA-MIS): Italian norms. *Neurological Sciences*, 46(6), 2581–2589. https://doi.org/10.1007/s10072-025-08066-1

De Renzi, E. (1982). *Disorders of space exploration and cognition*. John Wiley & Sons: Chichester.

De Renzi, E., Faglioni, P., & Scotti, G. (1970). Hemispheric contribution to exploration of space through the visual and tactile modality. *Cortex*, 6(2), 191–203. https://doi.org/10.1016/S0010-9452(70)80027-2

Demeyere, N., & Gillebert, C. R. (2019). Ego- and allocentric visuospatial neglect: Dissociations, prevalence, and laterality in acute stroke. *Neuropsychology*, 33, 490–498.

Diller, L., & Weinberg, J. (1977). Hemi-inattention in rehabilitation. The evolution of the rational remediation program. In Weinstein, E. A., & Friedland, R. P. (Eds.), *Hemi-inattention and hemisphere specialization* (pp. 62–82). New York: Raven Press.

Doricchi, F., Guariglia, P., Figliozzi, F., Silvetti, M., Bruno, G., & Gasparini, M. (2005). Causes of cross-over in unilateral neglect: Between-group comparisons, within-patient dissociations and eye movements. *Brain*, 128(Pt 6), 1386–1406. https://doi.org/10.1093/brain/awh461

Duncan, J., Bundesen, C., Olson, A., Humphreys, G., Chavda, S., & Shibuya, H. (1999). Systematic analysis of deficits in visual attention. *Journal of Experimental Psychology: General*, 128(4), 450–478. https://doi.org/10.1037/0096-3445.128.4.450

Esposito, E., Shekhtman, G., & Chen, P. (2021). Prevalence of spatial neglect post-stroke: A systematic review. *Annals of Physical and Rehabilitation Medicine*, 64(5), 101459. https://doi.org/10.1016/j.rehab.2020.10.010

Facchin, L., Vallar, G., & Daini, R. (2021). The Brentano illusion test (BRIT): An implicit task of perceptual processing for the assessment of visual field defects in neglect patients. *Journal of Clinical and Experimental Neuropsychology*, 43(4), 347–358. https://doi.org/10.1080/13803395.2020.1776701

Feigin, V. L., Brainin, M., Norrving, B., Martins, S. O., Pandian, J., Lindsay, P., et al. (2025). World stroke organization: Global stroke fact sheet 2025. *International Journal of Stroke*, 20(2), 132–144. https://doi.org/10.1177/17474930241308142

Ferber, S., & Karnath, H. O. (2001). How to assess spatial neglect—Line bisection or cancellation tasks? *Journal of Clinical and Experimental Neuropsychology*, 23(5), 599–607. https://doi.org/10.1076/jcen.23.5.599.1243

Fortis, P., Maravita, A., Gallucci, M., Ronchi, R., Grassi, E., Senna, I., et al. (2010). Rehabilitating patients with left spatial neglect by prism exposure during a visuomotor activity. *Neuropsychology*, 24(6), 681–697. https://doi.org/10.1037/a0019476

Gainotti, G., Messerli, P., & Tissot, R. (1972). Qualitative analysis of unilateral spatial neglect in relation to laterality of cerebral lesions. *Journal of Neurology, Neurosurgery and Psychiatry*, 35(4), 545–550. https://doi.org/10.1136/jnnp.35.4.545

Gainotti, G., & Trojano, L. (2018). Constructional apraxia. *Handbook of Clinical Neurology*, 151, 331–348. https://doi.org/10.1016/B978-0-444-63622-5.00016-4

Gauthier, L., Dehaut, F., & Joanette, Y. (1989). The bells test: A quantitative and qualitative test for visual neglect. *International Journal of Clinical Neuropsychology*, 11, 49–54.

Giannakou, I., Lin, D., & Punt, D. (2022). Computer-based assessment of unilateral spatial neglect: A systematic review. *Frontiers in Neuroscience*, 16, 912626. https://doi.org/10.3389/fnins.2022.912626

Guariglia, C., Padovani, A., Pantano, P., & Pizzamiglio, L. (1993). Unilateral neglect restricted to visual imagery. *Nature*, 364(6434), 235–237. https://doi.org/10.1038/364235a0

Halligan, P. W., Fink, G. R., Marshall, J. C., & Vallar, G. (2003). Spatial cognition: Evidence from visual neglect. *Trends in Cognitive Sciences*, 7(3), 125–133. https://doi.org/10.1016/S1364-6613(03)00032-9

Halligan, P. W., & Marshall, J. C. (1993). When two is one: A case study of spatial parsing in visual neglect. *Perception*, 22(3), 309–312.

Heilman, K. M., & Valenstein, E. (1979). Mechanisms underlying hemispatial neglect. *Annals of Neurology*, 5(2), 166–170.

Hubbard, E. J., Santini, V., Blankevoort, C. G., Volkers, K. M., Barrup, M. S., Byerly, L., et al. (2008). Clock drawing performance in cognitively normal elderly. *Archives of Clinical Neuropsychology*, 23(3), 295–327. https://doi.org/10.1016/j.acn.2007.12.003

Husain, M., Mannan, S., Hodgson, T., Wojciulik, E., Driver, J., & Kennard, C. (2001). Impaired spatial working memory across saccades contributes to abnormal search in parietal neglect. *Brain*, 124(5), 941–952. https://doi.org/10.1093/brain/124.5.941

Husain, M., Mattingley, J. B., Rorden, C., Kennard, C., & Driver, J. (2000). Distinguishing sensory and motor biases in parietal and frontal neglect. *Brain*, 123(Pt 8), 1643–1659.

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Husain, M., & Rorden, C. (2003). Non-spatially lateralized mechanisms in hemispatial neglect. *Nature Reviews Neuroscience*, 4(1), 26–36. https://doi.org/10.1038/nrn1005

Husain, M., Shapiro, K., Martin, J., & Kennard, C. (1997). Abnormal temporal dynamics of visual attention in spatial neglect patients. *Nature*, 385(6612), 154–156. https://doi.org/10.1038/385154a0

Huygelier, H., Moore, M. J., Demeyere, N., & Gillebert, C. R. (2020). Non-spatial impairments affect false-positive neglect diagnosis based on cancellation tasks. *Journal of the International Neuropsychological Society*, 26(7), 668–678. https://doi.org/10.1017/S1355617720000041

Jewell, G., & McCourt, M. E. (2000). Pseudoneglect: A review and meta-analysis of performance factors in line bisection tasks. *Neuropsychologia*, 38(1), 93–110.

Laiacona, M., Inzaghi, M. G., De Tanti, A., & Capitani, E. (2000). Wisconsin card sorting test: A new global score, with Italian norms, and its relationship with the Weigl sorting test. *Neurological Sciences*, 21(5), 279–291.

Lannoo, E., & Vingerhoets, G. (1997). Flemish normative data on common neuropsychological tests: Influence of age, education, and gender. *Psychologica Belgica*, 37(3), 141–155.

Laplane, D., & Degos, J. D. (1983). Motor neglect. *Journal of Neurology, Neurosurgery & Psychiatry*, 46(2), 152–158.

Lunven, M., & Bartolomeo, P. (2017). Attention and spatial cognition: Neural and anatomical substrates of visual neglect. *Annals of Physical and Rehabilitation Medicine*, 60(3), 124–129. https://doi.org/10.1016/j.rehab.2016.01.004

Malhotra, P., Jäger, H. R., Parton, A., Greenwood, R., Playford, E. D., Brown, M. M., et al. (2005). Spatial working memory capacity in unilateral neglect. *Brain*, 128(2), 424–435. https://doi.org/10.1093/brain/awh372

Mancuso, M., Damora, A., Abbruzzese, L., Navarrete, E., Basagni, B., Galardi, G., et al. (2019). A new standardization of the bells test: An Italian multi-center normative study. *Frontiers in Psychology*, 9, 2745. https://doi.org/10.3389/fpsyg.2018.02745

Mancuso, M., Rosadoni, S., Capitani, D., Bickerton, W. L., Humphreys, G. W., De Tanti, A., et al. (2015). Italian standardization of the apples cancellation test. *Neurological Sciences*, 36(7), 1233–1240. https://doi.org/10.1007/s10072-015-2088-2

Milner, A. D., Harvey, M., Roberts, R. C., & Forster, S. V. (1993). Line bisection errors in visual neglect: Misguided action or size distortion? *Neuropsychologia*, 31(1), 39–49. https://doi.org/10.1016/0028-3932(93)90079-F

Moore, M., Milosevich, E., Beisteiner, R., Bowen, A., Checketts, M., Demeyere, N., et al. (2022). Rapid screening for neglect following stroke: A systematic search and European academy of neurology recommendations. *European Journal of Neurology*, 29(9), 2596–2606. https://doi.org/10.1111/ene.15381

Na, D. L., Adair, J. C., Kang, Y., Chung, C. S., Lee, K. H., & Heilman, K. M. (1999). Motor perseverative behavior on a line cancellation task. *Neurology*, 52(8), 1569–1576.

Nys, G. M., van Zandvoort, M. J., van der Worp, H. B., Kappelle, L. J., & de Haan, E. H. F. (2006). Neuropsychological and neuroanatomical correlates of perseverative responses in subacute stroke. *Brain*, 129, 2148–2157. https://doi.org/10.1093/brain/awl199

Ogourtsova, T., Souza Silva, W., Archambault, P. S., & Lamontagne, A. (2017). Virtual reality treatment and assessments for post-stroke unilateral spatial neglect: A systematic literature review. *Neuropsychological Rehabilitation*, 27(3), 409–454. https://doi.org/10.1080/09602011.2015.1113187

Okamoto, T., & Mano, T. (2023). Chronological rehabilitation treatment varying by stage for constructive disability. *Clinical Practice*, 13, 917–923.

Ortigue, S., Viaud-Delmon, I., Michel, C. M., Blanke, O., Annoni, J. M., Pegna, A., et al. (2003). Pure imagery hemi-neglect of far space. *Neurology*, 60(12), 2000–2002. https://doi.org/10.1212/01.WNL.0000068028.63291.B6

Ota, H., Fujii, T., Suzuki, K., Fukatsu, R., & Yamadori, A. (2001). Dissociation of body-centered and stimulus-centered representation in unilateral neglect. *Neurology*, 57, 2064–2069. https://doi.org/10.1212/wnl.57.11.2064

Pia, L., Folegatti, A., Guagliardo, M., Genero, R., & Gindri, P. (2009). Are drawing perseverations part of the neglect syndrome? *Cortex*, 45, 293–299. https://doi.org/10.1016/j.cortex.2007.11.015

Pierce, J. E., Ronchi, R., Thomasson, M., Rossi, I., Casati, C., Saj, A., et al. (2022). A novel computerized assessment of manual spatial exploration in unilateral spatial neglect. *Neuropsychological Rehabilitation*, 32(6), 1099–1120. https://doi.org/10.1080/09602011.2021.1875850

R Core Team (2021). *R: A language and environment for statistical computing (version 4.1.0) [computer software]*. Vienna, Austria: R Foundation for Statistical Computing. https://cran.r-project.org

Robertson, I. H. (2001). Do we need the "lateral" in unilateral neglect? Spatially nonselective attention deficits in unilateral neglect and their implications for rehabilitation. *Neuro Image*, 14(1 Pt 2), S85–S90. https://doi.org/10.1006/nimg.2001.0838

Robertson, I. H., Mattingley, J. B., Rorden, C., & Driver, J. (1998). Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness. *Nature*, 395(6698), 169–172. https://doi.org/10.1038/25993

Robertson, I. H., Tegnér, R., Tham, K., Lo, A., & Nimmo–Smith, I. (1995). Sustained attention training for unilateral neglect: Theoretical and rehabilitation implications. *Journal of Clinical and Experimental Neuropsychology*, 17(3), 416–430.

Rode, G., Perenin, M. T., & Boisson, D. (1995). Négligence de l'espace représenté: Mise en évidence par l'évocation mentale de la carte de France [neglect of the representational space: Demonstration by mental evocation of the map of France]. *Revue Neurologique*, 151(3), 161–164.

Rode, G., Revol, P., Rossetti, Y., Boisson, D., & Bartolomeo, P. (2007). Looking while imagining: The influence of visual input on representational neglect. *Neurology*, 68(6), 432–437.

Ronchi, R., Algeri, L., Chiapella, L., Spada, M. S., & Vallar, G. (2012). Spatial neglect and perseveration in visuomotor

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

exploration. *Neuropsychology*, 26(5), 588–603. https://doi.org/10.1037/a0029216

Ronchi, R., Posteraro, L., Fortis, P., Bricolo, E., & Vallar, G. (2009). Perseveration in left spatial neglect: Drawing and cancellation tasks. *Cortex*, 45(3), 300–312. https://doi.org/10.1016/j.cortex.2008.03.012

RStudio Team (2020). *RStudio: Integrated development for R [computer software]*. http://www.rstudio.com/. Boston, MA, USA: RStudio, PBC.

Rusconi, M. L., Maravita, A., Bottini, G., & Vallar, G. (2002). Is the intact side really intact? Perseverative responses in patients with unilateral neglect: A productive manifestation. *Neuropsychologia*, 40(6), 594–604. https://doi.org/10.1016/s0028-3932(01)00160-9

Russell, C., Deidda, C., Malhotra, P., Crinion, J. T., Merola, S., & Husain, M. (2010). A deficit of spatial remapping in constructional apraxia after right-hemisphere stroke. *Brain*, 133, 1239–1251.

Saj, A., Verdon, V., Hauert, C. A., & Vuilleumier, P. (2018). Dissociable components of spatial neglect associated with frontal and parietal lesions. *Neuropsychologia*, 115, 60–69. https://doi.org/10.1016/j.neuropsychologia.2018.02.021

Sapir, A., Kaplan, J. B., He, B. J., & Corbetta, M. (2007). Anatomical correlates of directional hypokinesia in patients with hemispatial neglect. *Journal of Neuroscience*, 27(15), 4045–4051. https://doi.org/10.1523/JNEUROSCI.0041-07.2007

Schenkenberg, T., Bradford, D. C., & Ajax, E. T. (1980). Line bisection and unilateral visual neglect in patients with neurologic impairment. *Neurology*, 30(5), 509–517. https://doi.org/10.1212/WNL.30.5.509

SINP - Società Italiana di Neuropsicologia, in collaborazione con: A.L.I.Ce. Italia, AIP, AISN, AITO, FLI, FNOPI, GIRN, SIMFER, SIN, SINDEM, SIPF, SIRN, SPAN (2024). *Linee guida per la diagnosi e la riabilitazione dell'eminegligenza spaziale (neglect) nel paziente con ictus*. Rome, Italy: Sistema Nazionale Linee Guida.

Song, J., Cataldo, E., Thomasson, M., Saj, A., Vuilleumier, P., Ronchi, R., et al. (2025). From acute neglect to chronic constructional deficits: Parietotemporal contributions to long-term post-stroke impairments. *Brain. Communications*, 7(6), fcaf477. https://doi.org/10.1093/braincomms/fcaf477

Sorita, E., Duclos, N. C., Puech, L., Chibaudel, Q., & Quillion-Dupré, L. (2025). Virtual reality in clinical evaluation of unilateral spatial neglect, anatomy of current trends: A scoping review. *Applied Neuropsychology: Adult*, 1–14. https://doi.org/10.1080/23279095.2024.2439844

Spinnler, H., & Tognoni, G. (1987). Standardizzazione e taratura italiana di test neuropsicologici. *The Italian Journal of Neurological Sciences*, 8(Suppl. 8), 1–120.

Tegnér, R., & Levander, M. (1991). Through a looking glass: A new technique to demonstrate directional hypokinesia in unilateral neglect. *Brain*, 114(4), 1943–1951. https://doi.org/10.1093/brain/114.4.1943

Terruzzi, S., Albini, F., Massetti, G., Etzi, R., Gallace, A., & Vallar, G. (2024). The neuropsychological assessment of unilateral spatial neglect through computerized and virtual reality tools: A scoping review. *Neuropsychology Review*, 34(2), 363–401. https://doi.org/10.1007/s11065-023-09586-3

The jamovi project (2024). *Jamovi (version 2.5) [computer software]*. Sydney, Australia: The jamovi project. https://www.jamovi.org

Vallar, G. (1998). Spatial hemineglect in humans. *Trends in Cognitive Sciences*, 2(3), 87–97. https://doi.org/10.1016/S1364-6613(98)01145-0

Vallar, G. (2000). The methodological foundations of human neuropsychology: Studies in brain-damaged patients. In Boller, F., Grafman, J., & Rizzolatti, G. (Eds.), *Handbook of neuropsychology* (2nd ed., pp. 305–344). Amsterdam, The Netherlands: Elsevier Science.

Vallar, G., & Bolognini, N. (2014). Unilateral spatial neglect. In Nobre, A. C., & Kastner, S. (Eds.), *The Oxford handbook of attention* (pp. 972–1027). Oxford, UK: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199675111.013.012

Vallar, G., Burani, C., & Arduino, L. S. (2010). Neglect dyslexia: A review of the neuropsychological literature. *Experimental Brain Research*, 206(2), 219–235. https://doi.org/10.1007/s00221-010-2386-0

Vallar, G., & Calzolari, E. (2018). Unilateral spatial neglect after posterior parietal damage. In *Handbook of clinical neurology* (Vol. 151, pp. 287–312). Amsterdam, The Netherlands: Elsevier. https://doi.org/10.1016/B978-0-444-63622-5.00014-0

Vallar, G., & Maravita, A. (2009). Personal and extra-personal spatial perception. In Berntson, G. G., & Cacioppo, J. T. (Eds.), *Handbook of neuroscience for the behavioral sciences* (Vol. 1, pp. 322–336). Hoboken, NJ: John Wiley & Sons.

Vallar, G., & Perani, D. (1986). The anatomy of unilateral neglect after right-hemisphere stroke lesions: A clinical/CT-scan correlation study in man. *Neuropsychologia*, 24(5), 609–622. https://doi.org/10.1016/0028-3932(86)90001-1

Vallar, G., & Ronchi, R. (2022). Unilateral spatial neglect. In Della Sala, S. (Ed.), *Encyclopedia of behavioral neuroscience* (pp. 605–618). Amsterdam, The Netherlands: Elsevier. https://doi.org/10.1016/B978-0-12-819641-0.00144-4

Vallar, G., Rusconi, M. L., Fontana, S., & Musicco, M. (1994). Tre test di esplorazione visuo-spaziale: Taratura su 212 soggetti normali. *Archivio di Psicologia, Neurologia e Psichiatria*, 55(4), 827–841.

Vallar, G., Rusconi, M. L., Geminiani, G., Berti, A., & Cappa, S. F. (1991). Visual and nonvisual neglect after unilateral brain lesions: Modulation by visual input. *International Journal of Neuroscience*, 61(3–4), 229–239. https://doi.org/10.3109/00207459108990740

Vallar, G., Zilli, T., Gandola, M., & Bottini, G. (2006). Productive and defective impairments in the neglect syndrome: Graphic perseveration, drawing productions, and optic prism exposure. *Cortex*, 42(6), 911–920.

Verdon, V., Schwartz, S., Lovblad, K. O., Hauert, C. A., & Vuilleumier, P. (2010). Neuroanatomy of hemispatial neglect and its functional components: A study using voxel-based lesion-symptom mapping. *Brain*, 133(Pt 3), 880–894. https://doi.org/10.1093/brain/awp305

Veronelli, L., & Vallar, G. (2025). Left- and right-side unilateral spatial neglect: Hemispheric differences. *Handbook of Clinical Neurology*, 208, 127–154. https://doi.org/10.1016/B978-0-443-15646-5.00025-7

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

Wilson, B., Cockburn, J., Halligan, P., Spinazzola, L., Pagliari, C., & Beschin, N. (2010). *BIT: Behavioural inattention test [Italian adaptation]*. Florence, Italy: Giunti OS.

Wilson, B., Cockburn, J., & Halligan, P. W. (1987). *Behavioural inattention test*. Bury St Edmunds, UK: Thames Valley Test Company.

Downloaded from https://academic.oup.com/acn/article/41/3/acag018/8539762 by guest on 25 March 2026

© The Author(s) 2026. Published by Oxford University Press.This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com.
Archives of Clinical Neuropsychology, 2026, 41, acag018
https://doi.org/10.1093/arclin/acag018
Original Empirical Article