


Aligning formal and functional assessments of Visuospatial Neglect: A mixed-methods study

Margaret Jane Moore^a, Rebecca Driscoll^a, Michael Colwell^a, Olivia Hewitt^b and Nele Demeyere ^a

^aDepartment of Experimental Psychology, Radcliffe Observatory Quarter, University of Oxford, Oxford, UK; ^bOxford Institute of Clinical Psychology Training and Research, Isis Education Centre, Warneford Hospital, Oxford, UK

ABSTRACT

The occurrence of visuospatial neglect acts as a key predictor of recovery outcome following stroke. However, the specific behavioural profiles associated with various neglect subtypes are not well understood. This study aims to identify real-world functional impairments associated with neglect, to determine whether functional impairment profiles differ across patients with egocentric and allocentric neglect, and to investigate how neglect severity predicts functional impairments.

Notes from 290 stroke patients' occupational therapy functional assessments were qualitatively and quantitatively analysed in the context of neglect type and severity as reported by the OCS Cancellation Task. Overall, neglect patients had more references to having difficulty initiating tasks, finding items, exhibiting spatial inattention, and having difficulty using both arms than patients without neglect. The proportion of these references did not differ significantly across patients with egocentric and allocentric neglect. The quantitative severity of egocentric neglect was acted as a significant predictor of reference occurrence over and above stroke severity within difficulty finding items, spatial inattention, body inattention, and upper limb use.

This study expands on previous findings by identifying real-world functional impairments differentiating patients with and without neglect. This data provides novel insight into the impact of neglect on functional abilities.

ARTICLE HISTORY

Received 8 June 2021
Accepted 6 August 2021

KEYWORDS

Stroke; Visuospatial neglect; Functional impact; Attention; Occupational therapy

Introduction

Existing literature has strongly suggested that visuospatial neglect in acute stroke is associated with poor functional outcomes (Cherney et al., 2001; Jehkonen et al., 2000; Katz et al., 1999; Moore et al., 2021). This particularly robust

CONTACT Margaret Jane Moore  margaret.moore@psy.ox.ac.uk  Department of Experimental Psychology, Radcliffe Observatory Quarter, University of Oxford, Oxford OX2 6GG, UK

© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

effect has been documented across a wide range of functional outcome measures (Moore & Demeyere, 2021). However, studies have focused on identifying domain-general functional impairment rather than specific behavioural patterns in patients exhibiting neglect. For example, investigations that have employed standardized questionnaires as outcome measures have identified differences in aggregate scores rather than specific behavioural patterns which may differ between patients with and without visuospatial neglect impairment (Bickerton et al., 2011; Cherney et al., 2001; Jehkonen et al., 2000; Katz et al., 1999). To guide therapists and care workers toward the best approach for assisting participants with neglect deficits, it is crucial to identify the specific functional impairments in activities of daily life and how they align with formal test scores on an abstract cancellation task.

Qualitative data from occupational therapist notes collected as a standard component of post-stroke functional assessment can be employed to address this knowledge gap (Baum et al., 2008; Mohapatra & Kulnik, 2021). Occupational therapists regularly conduct structured, observational assessments to determine patient's ability to complete common daily life activities and suitability for discharge (Katz et al., 2000; Mohapatra & Kulnik, 2021). Two common classes of these real-world observational assessments are kitchen-related tasks and wash and dress assessments. In a kitchen assessment, a therapist might ask a patient to prepare a simple meal or a hot drink in a kitchen. Therapists then observe patients completing the assigned task, whilst taking note of any notable behavioural patterns (Baum et al., 2008; Mohapatra & Kulnik, 2021). These include motor impairments, cognitive deficits, and any other behaviours which might prove dangerous following discharge. In a wash/dress assessment, a therapist observes patients as they wash and dress themselves in a manner similar to what they would expect to do following discharge (Ebrahim et al., 1985; Walker & Lincoln, 1991; Whiting & Lincoln, 1980). Therapists take note of mobility, range of movement, cognition, mood, and general independence while washing and dressing. These notes are then employed to inform discharge date, destination, and level of required assistance.

Therapists' notes collected within these standard assessments offer a wealth of data that can be employed to identify patterns of observed behavioural impairment associated with common post-stroke impairments. Previous research has established strong correlations between kitchen-related task performance and neuropsychological memory, language, and attention assessments (Baum et al., 2008; Katz et al., 2000). Walker and Lincoln (Walker & Lincoln, 1991) found that patient performance on observational wash and dress assessments was highly correlated with scores on standardized physical and cognitive assessments, including visuospatial abilities as reported by a neuropsychological cancellation task. However, these previous investigations largely identified associations between cognitive impairments and low overall scores, rather than determining the specific profile of behavioural impairments associated with specific cognitive deficits.

In addition to complex behavioural profiles, visuospatial neglect is not a unitary syndrome but is instead a cluster of independent deficits. Previous research has suggested that egocentric (body-centred) and allocentric (object-centred) neglect may be associated with different functional outcomes. Bickerton et al. (Bickerton et al., 2011) found that patients with allocentric neglect scored lower on the Barthel Index activities of daily life measurement (Quinn et al., 2011) compared to patients with egocentric neglect. Patients with both allocentric and egocentric neglect also reported higher levels of depression than patients with either neglect type alone (Bickerton et al., 2011). Moore et al. (2021) found that the severity of acute allocentric, but not egocentric neglect acts as a predictor of poor, long-term Stroke Impact Scale scores. This documented differential impact of egocentric/allocentric neglect implies that it is not only important to identify the specific functional impact of the neglect syndrome as a whole, but it is also necessary to distinguish between behavioural phenotypes which are associated with egocentric and allocentric neglect impairment.

This study aims to clarify how neglect subtype and severity are associated with specific behavioural patterns. Specifically, this study aims to determine how egocentric and allocentric neglect impairment are independently predictive of real-world behavioural impairments. This more detailed understanding brings with it potential clinical applications: First, developing a more thorough understanding of how neglect impacts behaviour offers an avenue for improving the efficiency of observational neglect assessments. Second, it is not yet well understood how quantitative neglect severity scores translate into qualitative behavioural impairments. Gaining a better understanding of how neglect severity scales with specific functional impairments can potentially help clinician distinguish between patients who may be able to compensate for their attentional impairment, and those who will require assistance in daily tasks. Finally, establishing a detailed profile of specific behavioural impairments associated with egocentric/allocentric neglect could inform whether more tailored behaviour-based rehabilitation studies should be developed for these deficits. This study aims to identify specific functional impairments associated with the neglect syndrome, to determine whether functional impairment profiles differ across patients with egocentric and allocentric neglect, and to investigate how neglect severity scales with functional impairments.

Methods

Participants

This study represents a secondary analysis of data collected as a component of Oxford Cognitive Screen (OCS) studies between 2015 and 2020. These protocols were approved by the National Research Ethics Committee (11/WM/0299,14/

LO/0648). All participants provided informed consent in line with the Declaration of Helsinki. Participants were included if they completed the OCS Cancellation Task and had a documented systematic wash and dress and/or kitchen occupational therapy observational assessment within the first three weeks following stroke. In total, 290 patients (age = 73.4(range = 18–94), 43.3% female, 7.6% left handed) were included in this investigation. This sample contained 228 ischemic stroke, 42 haemorrhagic stroke, and 11 unreported stroke type patients. Stroke locations were recorded from routine clinical imaging as 125 right hemisphere, 69 left hemisphere, 24 bilateral, 51 not yet visible, and 12 unreported. This sample had an average National Institutes of Health Stroke Scale total score of 0.71(SD = 0.455, range = 0–23).

Functional assessment and qualitative analysis

Occupational therapist notes from structured wash and dress and kitchen assessments were collected from patient clinical notes records at the John Radcliffe Hospital acute stroke unit(Oxford, UK). In kitchen assessments, patients were systematically observed whilst making a cup of tea. In wash/dress assessments, patients were systematically observed whilst showering and dressing. This data was qualitatively analysed to identify overarching themes. In this analysis, all occupational therapy notes were transcribed in note form and imported into NVivo v.12 (Castleberry, 2014). The notes were analysed using thematic analysis, according to the guidelines provided by Braun & Clarke (Braun & Clarke, 2006). This analysis involves a recursive process through a series of six stages. First, analysts (BD and MC) familiarized themselves with data and generated initial themes. These themes were then searched for, reviewed, and defined. Throughout this process, codes were continually reviewed with themes being created or refined when necessary. The resultant thematic structure was independently reviewed and approved by OH. Themes that included a minimum of 20 references were included in this investigation's quantitative analyses. This threshold was established to reduce the risk of uninformative null results by ensuring that references with very low power to detect large effects were not analysed. Notably, only 113 patients completed both functional assessments meaning that different (but overlapping) samples are included in kitchen ($N = 142$) versus wash/dress assessment ($N = 234$) analyses.

Neglect testing and Quantitative Analysis

The OCS Cancellation Task was used to detect visuospatial neglect impairment. This assessment has been demonstrated to be highly sensitive to neglect and to reliably distinguish between egocentric and allocentric neglect deficits (Demeyere et al., 2015). In this task, participants are presented with a search

matrix of 150 complete and incomplete heart line drawings which are pseudo-randomly scattered across an A4 sheet (Figure 1). Participants are instructed to search through this matrix and mark all complete hearts whilst ignoring all incomplete stimuli. Participants are given two practice trials and are allowed three minutes to complete this task.

Egocentric neglect impairment is scored by subtracting the total number of targets correctly identified on the left side of the page from the number correctly identified on the right side (Demeyere et al., 2015). Spatial asymmetry scores <-3 or >3 are considered to represent significant neglect. A centre of cancellation measure (Rorden & Karnath, 2010) was employed to quantify egocentric neglect severity on a continuous scale. This score was calculated by assigning each response a numerical weight according to its horizontal location, with the average response weight determining the centre of cancellation egocentric severity score (Figure 1).

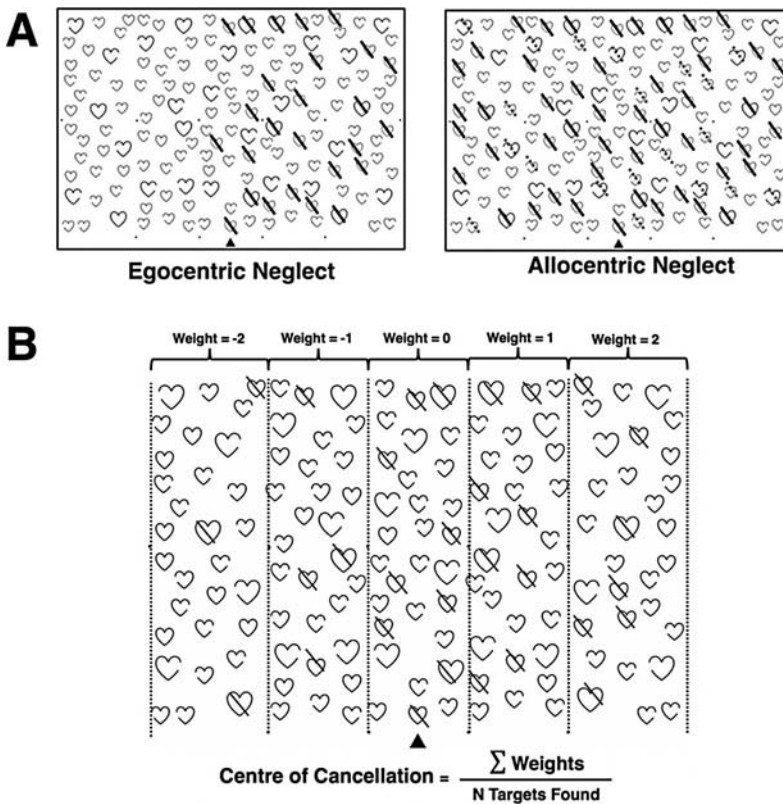


Figure 1. A visualization of egocentric and allocentric neglect deficits as detected by the OCS cancellation task (Panel A). Patients with egocentric neglect fail to report targets on one side of space while patients with allocentric neglect commit consistently lateralized false positive errors (highlighted in red). Panel B presents the task scoring grid, corresponding error weights, and equation for calculating centre of cancellation neglect severity scores.

The presence of allocentric neglect impairment is calculated by subtracting the number of right-gap false positive responses from the number of left-gap false positives. Allocentric asymmetry of <-1 or >1 represents impairment (Demeyere et al., 2015). Allocentric severity was calculated by dividing the OCS allocentric asymmetry score by the total number of targets identified in the cancellation task. For both egocentric and allocentric impairment, negative scores represent right neglect impairment and positive scores represent left-lateralized neglect. Patients exhibiting no significant neglect impairment on the cancellation task were classed as “neglect controls.” These patients were recruited in the same consecutive sample as the neglect patients, in the same setting and simply defined as “neglect controls” when no neglect was detected on the OCS.

This Cancellation Task data was then employed to complete quantitative analyses across the themes identified within this investigation’s qualitative analyses. First, the occurrence and severity of neglect impairment were compared across participant groups defined by their performance on the functional assessments. For each considered reference category, patient groups were dichotomized according to the presence or absence of a category reference and chi-squared analyses were performed to investigate the association between the presence and/or type of neglect across groups. Next, binary regressions were conducted to determine the relationship between neglect severity and subtheme references. Admission NIHSS total scores were included as a covariate within these analyses to control for stroke severity (Goldstein & Samsa, 1997). Unreported NIHSS data (N=52) was imputed by replacing missing values with the sample average (average NIHSS = 0.71).

Results

Qualitative analysis results

Overall, 142 participants completed kitchen assessment and 234 completed wash/dress assessment, with 113 patients having data for both assessments. Performance on these two assessments was analysed separately as qualitative analysis of each yielded different themes. Six overarching themes were identified within the occupational therapist notes from kitchen assessments: Independence, Attention, Physical, Cognition, Safety, and Emotions/Cognitions (Table 1). *Independence* encompassed references to patients who were able to effectively and safely complete the kitchen assessment with no assistance. The *Attention* theme included reports of participants’ awareness of their bodies and space. This theme’s subthemes consider whether patients demonstrate good body attention, remain aware of both sides of space, locate items, and remain focused. The *Physical* theme covered patients’ ability to maneuver themselves, maintain balance, employ fine motor skills, and reach

Table 1. A description of each theme and subtheme identified in qualitative analysis of kitchen assessment occupational therapist notes. The description column contains a summary of the criteria for reference occurrence and a breakdown of subthemes which were divided into qualitative categories denoting difference in impairment type or severity is also included within the division column.

Kitchen Assessment		
Themes/Subthemes	Description	Divisions
Independence	Completed assessment safely without assistance	N/A
Attention		
Body Attention	Use and attend to both hands when required without prompting	Uses Both Sides (Able, Difficulties), Lateralized Inattention
Spatial Attention	Able to attend well to space with no sign of lateralized inattention or non-spatial difficulty in finding items	Good Attention, Lateralized Inattention, Difficulty Finding
Reduced General Attention	Able to remain focused on the assessment with little distraction	N/A
Physical Aspects		
Mobilizing	Ability to move throughout the kitchen environment with ease	Able, Requires Supervision, Assistance Needed
Grip	Able to employ fine motor skills to handle items well	N/A
Balance	Remains balanced without relying on external support	Able, Poor, Uses Countertops for Support
Reaching	Able to access items in various locations easily	Able, Assistance Needed, Overreaching
Cognitive Aspects		
No Difficulties	Able to plan and execute task steps in the correct order and solve problems with no prompting	N/A
Difficulties	Required prompting to plan and execute task steps in the correct order and solve problems	N/A
Comprehension	Able to understand task instruction with minimal assistance	Good, Difficulties
Initiating/ Sequencing	Begins and Completes steps in the correct order without prompting	Able, Difficulties
Speech	Ability to express and understand speech	Good, Difficulties
Problem Solving	Solves problems without prompting	Good, Difficulties
Memory	Able to remember task instructions and progress	Good, Difficulties
Inappropriate Use	Uses objects in the intended manner	N/A
Safety		
Safe in Task	Able to complete all task aspects safely without intervention	N/A
Unsafe in Task	Unable to complete task aspects safely without intervention.	N/A
Liquid Pouring	Able to pour hot water safely without intervention	Able, Assistance Needed, Overfilled, Spilled, Underfilled
Emotions/Cognitions	Encompasses alertness/responsiveness, confidence, and insight into difficulties	N/A

objects. Cognition encompassed comprehension of instructions and ability to initiate, sequence, and complete steps in the correct order. These subthemes include the degree of guidance and prompting required to solve problems. *Safety* covers whether significant safety concerns were noted in the occupational notes, especially when preparing hot liquids. Finally, the *Emotions/Insight* domain includes broad observations of patients' alertness, fatigue level, confidence, and insight into their ability level.

Similarly, six overarching themes emerged from qualitative analysis of wash/dress assessment data: Independence, Attention, Cognition, Dressing

Assistance, Balance, and Emotions/Insight. The *Independence*, *Attention*, *Cognition*, and *Emotions/Insight* encompassed similar topics as the corresponding domains within the kitchen assessment (Table 2). The *Dressing Assistance* theme covered patients' ability to orient their clothing correctly, employ fine motor skills to fasten buttons/zips, and employ physical/spatial attentional skills to dress both sides of the body adequately. The *Balance* domain included patients' general ability to remain steady as well as any consistently lateralized midline deviations. Overall, 26 were included in this investigation's analyses.

Table 2. A description of each wash and dress theme and subtheme. The description column contains a summary of the criteria for reference occurrence and a breakdown of subthemes which were divided into qualitative categories denoting difference in impairment type or severity is also included within the divisions column.

Wash/Dress Assessment			
Themes/ Subthemes	Description		Divisions
Independence			
Minimal Assistance	Able to complete task with minimal assistance		N/A
Attention			
Body Attention	Use and attend to both hands when required without prompting		Good, Lateralized Inattention, Upper Limbs (Coordinated, Difficulties, Unable)
Spatial Attention	Able to attend well to space with no sign of lateralized inattention or non-spatial difficulty in finding items		Good, Lateralized Inattention
Reduced General Attention	Able to remain focused on the assessment with little distraction		N/A
Cognitive Aspects			
No Difficulties	Able to plan and execute task steps in the correct order and solve problems with no prompting		N/A
Problem Solving	Required prompting to plan and execute task steps in the correct order and solve problems		Able, Difficulties
Memory	Able to remember task instructions and progress		Good, Difficulties
Initiation	Able to begin task steps without prompting		N/A
Sequencing/ Completion	Completes task steps in the correct order and finishes all steps		Good, Difficulties, Impulsivity
Inappropriate Use Speech	Uses objects in the intended manner Ability to express and understand speech		N/A Good, Difficulties
Dressing Assistance			
Lateralized Difficulty	Exhibits lateralized difficulty due to weakness or inattention		N/A
Orienting Clothing Fastenings	Orients clothing correctly with no assistance Able to open/close clothing fastenings without assistance		N/A N/A
Balance			
Good Balance	Consistently maintains midline balance with little deviations or support		N/A
Leaning to One Side	Exhibits consistently lateralized midline balance deviations		N/A
Emotions/Cognitions			
Fatigue	Able to complete task without exhibiting significant fatigue		N/A
Lack of Insight	Demonstrates awareness of abilities and difficulties		N/A
Other	Other emotions and cognitions		N/A

Quantitative analysis of reference frequencies

Next, this thematic structure was used to quantify functional differences between patients with and without neglect. Specifically, the proportion of patients with references to each identified theme was quantitatively compared across patients with and without significant neglect impairment. In total, 179/290 patients exhibited visuospatial neglect (age = 74, SD = 14.07) and 111 were classed as neglect controls (age = 75, SD = 12.76). Kitchen assessment data was available for 88 neglect patients (62 egocentric, 25 allocentric, 56 co-occurring egocentric and allocentric) and 54 controls. Similarly, 143 neglect patients (40 egocentric, 18 allocentric, 30 co-occurring egocentric and allocentric) and 91 controls had wash/dress data.

First, a series of two-tailed Fisher's Exact chi-squared analyses were conducted to identify differences in reference distributions across patients with and without significant visuospatial neglect. Given that 29 individual chi-squared tests were conducted, a Bonferroni-corrected alpha level of 0.0017 was employed. Within the kitchen assessment, patients with neglect (regardless of type or severity) were found to be significantly more likely to have references to difficulty finding items and challenges initiating/sequencing/completing tasks than patients without neglect (Table 3). Conversely, patients without neglect had significantly more references to needing assistance when mobilizing and pouring hot liquids, using both sides of the body well, attending well to both sides of space, and to being independent within the kitchen assessment than patients with any neglect impairment.

Within the Wash and Dress assessment, participants with neglect were found to have a significantly greater proportion of references to "challenges initiating," "lateralized spatial inattention," "difficulties attending to one side of the body," and an "inability to use both upper limbs." Patients without neglect had a significantly higher proportion of references to attending well to space, exhibiting good attention to the body, and completing the wash and dress assessment with minimal assistance than patients with neglect. Overall, participants exhibiting any visuospatial neglect deficit had a higher average proportion of references pertaining to impairments than patients without neglect (22.58% vs 17.02% respectively). Conversely, participants with no neglect had a higher average proportion of references to intact/good abilities than patients with neglect (36.48% vs 18.36% respectively).

Next, the distribution of references across participants exhibiting different neglect subtypes was investigated. No significant differences in the proportion of references made to each theme were identified between patients with pure egocentric and pure allocentric neglect (Table 4). Participants with both egocentric and allocentric neglect had a higher average proportion of references pertaining to impairments ($n = 169$ (30.7%)) than patients with pure egocentric ($n = 134$ (20.0%)) or pure allocentric ($n = 57$ (19.9%)) neglect. Conversely,

Table 3. A comparison of reference frequencies across participants with and without significant neglect impairment. See Tables 1 and 2 for a detailed description of each reference criteria.

	No Neglect	Neglect	Chi Value	<i>P</i>
Kitchen Assessment (N = 142)				
Independent	48 (88.9%)	37 (42.0%)	30.5611	<0.0001*
Able to Use Both Sides of Body	35 (64.8%)	23 (26.1%)	20.7203	<0.0001*
Difficulties Using Both Sides of Body	7 (13.0%)	24 (27.3%)	4.0156	0.0451
Good Spatial Attention	42 (77.8%)	25 (28.4%)	32.7289	<0.0001*
Difficulties Finding Items	1 (1.9%)	30 (34.1%)	20.3819	<0.0001*
Lateralized Inattention (Space)	3 (5.6%)	17 (19.3%)	5.2381	0.0221
Sequencing/Completing (Difficulties)	1 (1.9%)	33 (37.5%)	23.3526	<0.0001*
Initiating/Sequencing (Able)	12 (22.2%)	27 (30.7%)	1.2022	0.2729
Problem Solving (Able)	7 (13.0%)	14 (15.9%)	0.2305	0.6312
Emotions	3 (5.6%)	21 (23.9%)	7.9865	0.005
Balance (Poor)	9 (16.7%)	19 (21.6%)	0.5126	0.474
Mobilizing (Able)	35 (64.8%)	31 (35.2%)	11.7767	0.0006
Mobilizing (Assistance Needed)	35 (64.8%)	8 (9.1%)	49.2203	<0.0001*
Reaching (Able)	11 (20.4%)	12 (13.6%)	1.118	0.2904
Liquid Pouring (Assistance Needed)	33 (61.1%)	16 (18.2%)	27.2894	<0.0001*
Liquid Pouring (Able)	14 (25.9%)	29 (33.0%)	0.376204	0.7831
Safe in Task	15 (27.8%)	25 (28.4%)	0.0066	0.9353
Wash/Dress Assessment (N = 243)				
Minimal Assistance	42 (46.2%)	25 (17.5%)	22.3716	<0.0001*
Dressing (Lateralized Difficulty)	1 (1.1%)	31 (21.7%)	19.9507	<0.0001*
Body Attention (Good)	56 (61.5%)	15 (10.5%)	68.5679	<0.0001*
Lateralized Inattention (Body)	1 (1.1%)	30 (21.1%)	19.1238	<0.0001*
Upper Limb Use (Coordinates)	10 (20.1%)	14 (10.0%)	0.1681	0.6818
Upper Limb Use (Difficulties)	27 (29.6%)	42 (29.4%)	0.0024	0.9609
Good Spatial Attention	46 (50.5%)	10 (7.0%)	57.9549	<0.0001*
Lateralized inattention (Space)	1 (1.1%)	28 (20.6%)	17.4951	<0.0001*
Initiating (Challenges)	0	27 (18.9%)	16.8896	<0.0001*
Initiating (Good)	17 (18.9%)	26 (18.2%)	0.0093	0.9234
Fatigue	19 (20.9%)	13 (9.1%)	6.5462	0.0105
Upper Limb Use (Unable)	2 (2.2%)	42 (29.4%)	26.8941	<0.0001*

participants with both egocentric and allocentric neglect had a reduced average proportion of references pertaining to good abilities ($n = 102$ (18.5%)) compared to patients with either pure egocentric ($n = 148$ (22.1%)) or allocentric ($n = 63$ (22.0%)) neglect. However, chi-squared analyses revealed no significant differences between patients with both neglect types, pure egocentric, and pure allocentric in specific reference categories (Table 3).

The relationship between neglect severity and impairment

Next, binary linear regressions were conducted to determine whether reference probability scaled with egocentric neglect severity within the subthemes which contained a significantly different proportion of references across patients with and without neglect ($n = 15$). Each regression included the absolute value of egocentric severity (centre of cancellation) and NIHSS total scores as predictor variables with reference occurrence as the binarized outcome measure. Egocentric neglect severity's contribution to predicting references survived 5% False Discovery Rate correction within the analyses considering kitchen assessment difficulty finding items ($p > 0.001$, AIC = 113.08) as well as wash/dress

Table 4. A comparison of reference frequencies across participants with egocentric, allocentric, and both egocentric/allocentric neglect. See Tables 1 and 2 for a detailed description of each reference criteria.

	Egocentric	Allocentric	Both
Kitchen Assessment Theme			
Independence			
Independent	20 (50.0%)	6 (33.3%)	11 (36.7%)
Attention (Body)			
Uses both sides of body well	10 (25.0%)	5 (27.8%)	8 (26.7%)
Difficulties using both sides of body	6 (15.0%)	6 (33.3%)	12 (40.0%)
Attention (Spatial)			
Attending well to space	14 (35.0%)	4 (22.2%)	7 (23.3%)
Difficulties finding items	14 (35.0%)	4 (22.2%)	12 (40.0%)
Lateralized inattention (egocentric)	8 (20.0%)	1 (5.6%)	8 (26.7%)
Cognition			
Challenges initiating/sequencing/completing	13 (32.5%)	5 (27.8%)	15 (37.5%)
Good initiation/sequencing/completing	12 (30.0%)	8 (44.4%)	7 (17.5%)
Able to solve problems	7 (17.5%)	3 (16.7%)	4 (10.0%)
Emotions/Cognitions	9 (22.5%)	4 (22.2%)	8 (26.7%)
Physical			
Balance (poor balance)	8 (20.0%)	6 (33.3%)	5 (16.7%)
Mobilizing (able)	11 (27.5%)	4 (22.2%)	16 (40.0%)
Mobilizing (assistance needed)	3 (7.5%)	3 (16.7%)	2 (5.0%)
Reaching (able)	6 (15.0%)	3 (16.7%)	3 (7.5%)
Safety			
Liquid assistance needed	4 (10.0%)	4 (22.2%)	8 (26.7%)
Liquid correctly filled	15 (37.5%)	3 (16.7%)	11 (36.7%)
Safe in task	13 (32.5%)	5 (27.8%)	7 (17.5%)
Wash/Dress Assessment Theme			
Independence			
Completed with minimal assistance	11 (17.7%)	7 (28.0%)	7 (12.5%)
Assistance Needed			
Difficulty dressing one side	9 (14.5%)	6 (24.0%)	16 (28.6%)
Attention (Body)			
Good Attention to the body	6 (9.7%)	5 (20.0%)	4 (7.1%)
Inattention to one side of body	9 (14.5%)	5 (20.0%)	16 (28.6%)
Good Coordination of upper limbs	8 (12.9%)	2 (8.0%)	4 (7.1%)
Not Full use of both upper limbs	16 (25.8%)	6 (24.0%)	20 (35.7%)
Unable to use both upper Limbs	17 (27.4%)	6 (24.0%)	19 (33.9%)
Attention (Spatial)			
Attending well to space	5 (8.1%)	2 (8.0%)	1 (1.8%)
Lateralized inattention (egocentric)	11 (17.7%)	1 (4.0%)	16 (28.6%)
Cognition			
Initiating (challenges)	13 (21.0%)	3 (12.0%)	11 (19.6%)
Initiating (good)	10 (16.1%)	4 (16.0%)	12 (21.4%)
Emotions/Cognitions			
Fatigue	3 (4.8%)	1 (4.0%)	9 (16.1%)

assessment spatial inattention ($p = 0.004$, AIC = 141.2), body inattention ($p = 0.004$, AIC = 141.17), and lack of ability to use both upper limbs well ($p = 0.011$, AIC = 181.42) (Figure 2). Full results and statistics for all conducted comparisons are included within supplementary materials.

Next, 15 binary linear regressions were conducted to determine whether reference probability scaled with allocentric neglect severity. These regressions employed the absolute value of allocentric severity and NIHSS total as predictors and reference occurrence as the outcome variable. Allocentric severity's contribution to predicting reference occurrence did not survive 5% False Discovery Rate correction in any of the 15 conducted regressions.

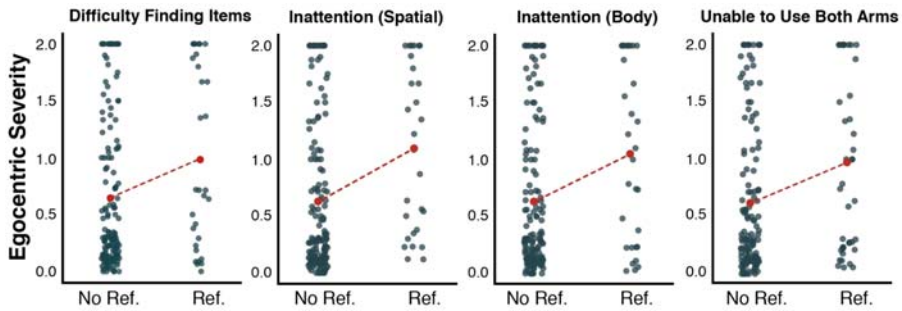


Figure 2. The relationship between egocentric neglect severity (*y*-axis) and subtheme reference (*x*-axis). Blue dots represent patient scores, red dots represent group means, and red lines visualize the difference in means between groups

Discussion

Overall, patients with neglect were found to have more references to having difficulty initiating tasks, finding items, exhibiting spatial inattention, and having difficulty using both arms than patients without neglect. The proportion of subtheme references was not found to differ significantly across patients with egocentric and allocentric neglect. However, participants with both egocentric and allocentric neglect had a higher average proportion of references pertaining to impairments than patients with egocentric or allocentric neglect alone. The quantitative severity of egocentric neglect impairment was found to act as a significant predictor of reference occurrence over and above stroke severity alone within difficulty finding items, spatial inattention, body inattention, and upper limb use subthemes. The findings of this investigation align well with previous research by demonstrating the association between the occurrence of acute neglect and reduced functional abilities in stroke survivors. This study expands on previous findings by identifying specific functional impairments which differentiate between patients with and without neglect impairment. Overall, this data provides novel insight into the impact of visuospatial neglect on functional abilities.

First, patients with neglect were found to have significantly more references to some classical behavioural symptoms of unilateral visuospatial neglect including lateralized spatial inattention, difficulties attending to one side of the body, and difficulties finding items than patients without neglect impairment. Conversely, patients without neglect had significantly more references to attending well to space and exhibiting good attention to the body than patients with neglect. Several commonly employed observational neglect assessments such as the NIHSS and Catherine Bergego Scale base neglect diagnosis on classic behavioural neglect symptoms such as these (Azouvi et al., 2003). However, it is important to note that despite the difference in reference frequency between patients with and without neglect, only a comparatively

small fraction of patients with neglect were noted to have these behavioural impairments. Within the wash and dress assessment, only 20.6% of patients with neglect as reported by a standardized neuropsychological task were noted to exhibit signs of lateralized spatial inattention in functional assessment. Within the kitchen assessment, only 19.3% of neglect patients had references to spatial inattention with no significant difference in reference frequency from patients without neglect. These findings suggest that functional observation alone does not represent a sensitive method for diagnosing neglect impairment compared to gold-standard neuropsychological neglect assessments.

This finding is important to consider in the context of the current clinical practice for neglect diagnosis. Evald et al. (2020) conducted a large-scale survey of the methods used to detect and diagnose visuospatial neglect in clinical settings in which 90% of participating clinicians reported that they generally diagnosed neglect through observing patient behaviour. However, the results of this investigation suggest that only a small fraction of patients with neglect may exhibit overt, classical signs of spatial inattention in behavioural assessments. There are several possible explanations for this finding. First, it is possible that therapists only made note of patients exhibiting severe behavioural spatial inattention. Second, previous research has demonstrated that neglect tends to recover spontaneously within the first ten days following stroke (Stone et al., 1992). Finally, it is possible that observational assessments do not represent a sensitive method for diagnosing neglect impairment. Previous research has found that observational assessments frequently fail to detect cases of neglect regardless of impairment severity and commonly misclassify neglect impairment as visual deficits (Moore et al., 2019; Puig-Pijoan et al., 2018). Gottesman et al. (2009) that adding a simple, neuropsychological cancellation task to the traditionally observational NIHSS significantly improved this scale's ability to predict stroke severity. Considered in the context of these previous studies, the results of this investigation provide additional evidence that quantitative, neuropsychological testing is needed to accurately detect and diagnose visuospatial neglect deficits within clinical environments.

Next, patients with neglect were found to have a significantly higher proportion of references to difficulties initiating/sequencing than patients without neglect. This finding is particularly interesting as initiating difficulties are not classically associated with visuospatial neglect behavioural symptoms (Halligan et al., 1991). However, previous research has suggested that a subset of egocentric neglect cases may be associated with motor-intentional deficits (Husain et al., 2000; Mattingley et al., 1998). Mattingley et al. (1998) found that egocentric neglect patients with lesions impacting the right inferior parietal lobule exhibited difficulty initiating leftward movements. This impairment was not present in neglect patients with more anterior lesions (Mattingley et al., 1998). This conclusion is in line with the findings of this investigation in that initiating deficits were associated with neglect, but were not referenced in all neglect patients.

Patients with neglect were more also likely to have references to an inability to use both upper limbs than patients without neglect. This finding is likely partially accounted for by the motor impairments which have been associated with the neglect syndrome. Patients with visuospatial neglect are frequently unaware of the neglected side of their body and “motor neglect” is frequently observed in patients exhibiting visuospatial neglect (Mattingley et al., 1998; Parton et al., 2004; Punt & Riddoch, 2006). Motor neglect is characterized by an underutilization of one side in the absence of underlying strength or sensation impairments (Laplaine & Degos, 1983; Punt & Riddoch, 2006). Motor neglect is behaviourally doubly dissociated from visuospatial neglect, but these syndromes do frequently co-occur (Heilman et al., 2000; Laplane & Degos, 1983). Finally, neural regions which have been strongly implicated in the neglect syndrome are anatomically proximal to the primary motor cortex. Large strokes which impact neglect correlates are therefore likely to result in lateralized motor impairments. Finally, leftward motor-intentional deficits do not selectively impact contralesional limbs, but instead impact all leftward movements (Mattingley et al., 1998). Taken together, the established association between visuospatial neglect and motor impairments may help account for the documented association between neglect and references to upper limb movement deficits.

No significant difference in subtheme reference proportion was identified between patients with egocentric and allocentric impairment. As a whole, patients with both egocentric and allocentric neglect had a higher proportion of references to impairment than patients with egocentric or allocentric neglect alone. Previous research has indicated that some degree of difference in functional outcome is present between patients with different neglect subtypes. Bickerton et al. (2011) found that patients with allocentric neglect scored significantly lower on the Barthel Index activities of daily life measurement (Quinn et al., 2011) compared to patients with egocentric neglect. In this study, patients with both allocentric and egocentric neglect also reported significantly higher levels of depression on the Hospital Anxiety and Depression Scale than patients with either egocentric or allocentric neglect alone (Bickerton et al., 2011). It is possible that egocentric and allocentric neglect are associated with significant, but small behavioural differences which are not associated with large enough effect sizes to be apparent within occupational therapist observations. Alternatively, it is possible that allocentric and egocentric neglect differentially impact functional activities not assessed in either the wash and dress or kitchen assessment (e.g., reading). Additional research in even larger samples is needed to confirm whether behavioural profiles are analogous across these neglect subtypes.

The severity of egocentric neglect impairment was found to be predictive of references within four themes. Notably, this predictive relationship remained significant whilst including NIHSS total scores as a control for general stroke

severity. Within the wash and dress assessment, the severity of egocentric neglect predicted references to both spatial inattention and body inattention. Within the kitchen assessment, egocentric severity was significantly associated with references to difficulty finding items. This finding demonstrates the external validity of the severity scores yielded by the OCS Cancellation Task, as the severity of egocentric neglect as documented by this neuropsychological test predicts the occurrence of neglect deficits within real-world, functional activities. The severity of egocentric neglect was also found to predict references to more general functional activities which are less directly related to spatial attention. Neglect severity was correlated with references to patients being unable to use both upper limbs within the wash and dress assessment. This relationship may be partially accounted for by the association between personal neglect and egocentric neglect (Committeri et al., 2018), but may also be due to the high comorbidity between hemiplegia and neglect deficits (Parton et al., 2004). This relationship between severe egocentric neglect and more general functional abilities may be partially explained by general stroke severity, as larger lesions are more likely to cause neglect than smaller ones (de Haan & Karnath, 2018). However, this potential correlation does not negate the severity of egocentric neglect's role as a prognostic indicator associated with these specific behavioural patterns.

The severity of allocentric neglect was not found to significantly predict the occurrence of references within any identified theme categories. This finding may be accounted for by the differences in expected impact between egocentric and allocentric neglect. Body-centred attention must be employed to complete many functional activities, but the role object-level attention plays in these functional activities is less well understood. It seems plausible that allocentric neglect may be more apparent when completing tasks not tested within kitchen or wash-and-dress assessments such as reading or facial recognition (Brunn & Farah, 1991; Ptak et al., 2012). Future research could endeavour to clarify the impact of allocentric neglect on a more diverse range of activities of daily life.

In line with previous research, the visuospatial neglect syndrome as a whole was found to be associated with poor functional status. Patients with neglect were found to have a higher frequency of references to impaired behaviours than patients exhibiting no neglect impairment. Conversely, patients with neglect had fewer references to intact abilities in the functional assessments than patients without significant neglect impairment. Patients without neglect were more likely to need only minimal assistance within the wash and dress assessment and were more likely to be classed as independent within the kitchen assessment than patients with neglect. This finding largely replicates similar results documented by previous investigations (Bickerton et al., 2011; Cherney et al., 2001; Jehkonen et al., 2000; Nys et al., 2006; Ten Brink et al., 2017). However, unlike previous investigations, this study

documented the selective impact of neglect impairment across a range of specific behavioural references. The occurrence of neglect was not found to uniformly impact reference frequency across all subthemes, with some reference themes being equally likely to be used to describe patients with and without neglect. This finding is important to note as it suggests that the association between neglect and poor functional outcome is not simply driven by stroke severity. Patients without neglect were found to have more references to specific impairments (e.g., needing assistance when mobilizing and pouring hot liquids) than patients with neglect, suggesting that the behavioural differences observed in this study are not simply a product of difference in general stroke severity. Instead neglect seems to be associated with a more specific pattern of poor functional outcome which selectively impacts certain functional tasks while leaving others intact.

Cumulatively, this study provides novel insight into the specific functional impairment profile associated with visuospatial neglect. Patients with and without neglect were found to exhibit significantly different behavioural patterns within observational neglect assessments. The findings of this study are clinically relevant as they help predict the specific activities in which patients with neglect may experience comparatively higher levels of impairment. This information can be used by therapists to develop more detailed treatment plans, risk assessments, and care support networks for patients exhibiting visuospatial neglect. While observational assessments may not provide the most sensitive method for diagnosing neglect, these assessments provide undeniably critical daily life functional information which can be used to develop tailored rehabilitation strategies for patients both with and without neglect impairment.

Limitations

There are additional, independent subtypes of neglect which were not included in this investigation. Neglect can selectively impact additional spatial coordinates (e.g., peri-personal/extra-personal neglect [Butler et al., 2009; Ten Brink et al., 2019]) or sensory modalities (e.g., auditory neglect [Bellmann et al., 2001]). It is plausible that each of these additional neglect subtypes may be associated with distinct patterns of functional impairment. Additionally, previous research has strongly suggested that the most reliable method for detecting and diagnosing visuospatial neglect is requiring agreement between multiple, independent neuropsychological tests (Bowen et al., 1999; Huygelier et al., 2020). However, this recommendation is not commonly followed in clinical settings. For this reason, only data from a single cancellation task conducted was available in this investigation. Future research can aim to determine whether functional impairment scales with neglect type and severity as measured by a wider range of neuropsychological metrics.

Conclusion

The findings of this study provide novel insight into the specific functional impairment profile associated with the visuospatial neglect syndrome, aligning occupational therapist and cognitive neuropsychological assessments of neglect. In acute stroke wash and dress and kitchen assessments, patients with neglect were found to have more references to having difficulty initiating tasks, finding items, exhibiting spatial inattention, and having difficulty using both arms than patients without neglect. The proportion of subtheme references was not found to differ significantly across patients with egocentric and allocentric neglect. However, participants with both egocentric and allocentric neglect had a higher average proportion of references to impairments than patients with egocentric or allocentric neglect alone. The severity of egocentric neglect impairment acted as a significant predictor of reference occurrence within difficulty finding items, spatial inattention, body inattention, and upper limb use subthemes. Overall, this data provides novel insight into the impact of visuospatial neglect on functional abilities and provides additional evidence of the need for standardized, neuropsychological neglect testing within clinical settings.

Acknowledgements

We would like to express our sincere gratitude and admiration to the late Prof Glyn W Humphreys, who initiated the OCS work. The OCS study was supported by the National Institute for Health Research Clinical Research Network. We also acknowledge the contributions to data collection and curation made by Ms Rachel Teal, Ms Grace Chiu, Ms Romina Basting, and the occupational therapy team at the John Radcliffe Hospital's Hyper Acute Stroke Ward.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was funded by Stroke Association UK awards to ND (TSA2015_LECT02; TSA 2011/02) and MJM (SA PGF 18\100031), and was supported by the National Institute for Health Research (NIHR) Oxford Biomedical Research Centre (BRC) based at Oxford University Hospitals NHS Trust.

Author contributions

In line with Contributor Roles Taxonomy (CRediT) guidelines, MJM was responsible for Formal Analysis, Investigation, Visualization, Writing – Original Draft, and Writing – Editing & Reviewing. BD contributed to Data Curation, Investigation, and Writing – Original Draft. MC aided in Data Curation, Investigation,

Formal Analysis, and Writing – Original Draft. OH was responsible for qualitative analysis Supervision. Finally, ND was responsible for project Conceptualization, Supervision, and Writing – Reviewing and Editing.

Data availability statement

All anonymized data and analysis code is available on request from the authors.

ORCID

Nele Demeyere  <http://orcid.org/0000-0003-0416-5147>

References

- 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(1), 51–57. <https://doi.org/10.1053/apmr.2003.50062>
- Baum, C. M., Connor, L. T., Morrison, T., Hahn, M., Dromerick, A. W., & Edwards, D. F. (2008). Reliability, validity, and clinical utility of the executive function performance test: A measure of executive function in a sample of people with stroke. *American Journal of Occupational Therapy*, 62(4), 446–455. <https://doi.org/10.5014/ajot.62.4.446>
- Bellmann, A., Meuli, R., & Clarke, S. (2001). Two types of auditory neglect. *Brain*, 124(Pt 4), 676–687. <https://doi.org/10.1093/brain/124.4.676>
- Bickerton, W.-L., Samson, D., Williamson, J., & Humphreys G, W. (2011). Separating forms of neglect using the apples test: Validation and functional prediction in chronic and acute stroke. *Neuropsychology*, 25(5), 567–580. <https://doi.org/10.1037/a0023501>
- 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>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Brunn, J. L., & Farah, M. J. (1991). The relation between spatial attention and reading: Evidence from the neglect syndrome. *Cognitive Neuropsychology*, 8(1), 59–75. <https://doi.org/10.1080/02643299108253367>
- Butler, B. C., Lawrence, M., Eskes, G. A., & Klein, R. (2009). Visual search patterns in neglect: Comparison of peripersonal and extrapersonal space. *Neuropsychologia*, 47(3), 869–878. <https://doi.org/10.1016/j.neuropsychologia.2008.12.020>
- Castleberry, A. (2014). NVivo 10 [software program]. version 10. QSR international; 2012. *American Journal of Pharmaceutical Education*, 78(1). <https://doi.org/10.5688/ajpe78125>
- Cherney, L. R., Halper, A. S., Kwasnica, C. M., Harvey, R. L., & Zhang, M. (2001). Recovery of functional status after right hemisphere stroke: Relationship with unilateral neglect. *Archives of Physical Medicine and Rehabilitation*, 82(3), 322–328. <https://doi.org/10.1053/apmr.2001.21511>
- Committeri, G., Piervincenzi, C., & Pizzamiglio, L. (2018). Personal neglect: A comprehensive theoretical and anatomo-clinical review. *Neuropsychology*, 32(3), 269–279. <https://doi.org/10.1037/neu0000409>

- de Haan, B., & Karnath, H.-O. (2018). A hitchhiker's guide to lesion-behaviour mapping. *Neuropsychologia*, *115*, 5–16. <https://doi.org/10.1016/j.neuropsychologia.2017.10.021>
- Demeyere, N., Riddoch, M. J., Slavkova, E. D., Bickerton, W.-L., & Humphreys, G. W. (2015). The Oxford Cognitive Screen (OCS): Validation of a stroke-specific short cognitive screening tool. *Psychological Assessment*, *27*(3), 883–894. <https://doi.org/10.1037/pas0000082>
- Ebrahim, S., Nouri, F., & Barer, D. (1985). Measuring disability after a stroke. *Journal of Epidemiology & Community Health*, *39*(1), 86–89. <https://doi.org/10.1136/jech.39.1.86>
- Evald, L., Wilms, I., & Nordfang, M. (2020). Assessment of spatial neglect in clinical practice: A nationwide survey. *Neuropsychological Rehabilitation*, *0*(0), 1–16. <https://doi.org/10.1080/09602011.2020.1778490>
- Goldstein, L. B., & Samsa, G. P. (1997). Reliability of the National Institutes of Health Stroke scale. *Stroke*, *28*(2), 307–310. <https://doi.org/10.1161/01.STR.28.2.307>
- Gottesman, R. F., Kleinman, J. T., Davis, C., Heidler-Gary, J., Newhart, M., & Hillis, A. E. (2009). The NIHSS-plus: Improving cognitive assessment with the NIHSS. *Behavioural Neurology*, *22*(1, 2), 11–15. <https://doi.org/10.3233/BEN-2009-0259>
- Halligan, P. W., Cockburn, J., & Wilson, B. A. (1991). The behavioural assessment of visual neglect. *Neuropsychological Rehabilitation*, *1*(1), 5–32. <https://doi.org/10.1080/09602019108401377>
- Heilman, K. M., Valenstein, E., & Watson, R. T. (2000). Neglect and related disorders. *Seminars in Neurology*, *20*(4), 463–470. <https://doi.org/10.1055/s-2000-13179>
- Husain, M., Mattingley, J. B., Rorden, C., Kennard, C., & Driver, J. (2000). Distinguishing sensory and motor biases in parietal and frontal neglect. *Brain*, *123*(8), 1643–1659. <https://doi.org/10.1093/brain/123.8.1643>
- 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>
- Jehkonen, M., Ahonen, J.-P., Dastidar, P., Koivisto, A. M., Laippala, P., Vilkkii, J., & Molnar, G. (2000). Visual neglect as a predictor of functional outcome one year after stroke. *Acta Neurologica Scandinavica*, *101*(3), 195–201. <https://doi.org/10.1034/j.1600-0404.2000.101003195.x>
- 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*(4), 379–384. [https://doi.org/10.1016/S0003-9993\(99\)90273-3](https://doi.org/10.1016/S0003-9993(99)90273-3)
- Katz, N., Hartman-Maeir, A., Ring, H., & Soroker, N. (2000). Relationships of cognitive performance and daily function of clients following right hemisphere stroke: Predictive and ecological validity of the LOTCA battery. *The Occupational Therapy Journal of Research*, *20*(1), 3–17. <https://doi.org/10.1177/153944920002000101>
- Laplane, D., & Degos, J. D. (1983). Motor neglect. *Journal of Neurology, Neurosurgery & Psychiatry*, *46*(2), 152–158. <https://doi.org/10.1136/jnnp.46.2.152>
- Mattingley, J. B., Husain, M., Rorden, C., Kennard, C., & Driver, J. (1998). Motor role of human inferior parietal lobe revealed in unilateral neglect patients. *Nature*, *392*(6672), 179–182. <https://doi.org/10.1038/32413>
- Mohapatra, S., & Kulnik, S. T. (2021). Kitchen-related tasks used in occupational therapy during rehabilitation of adults with acquired brain injury: A systematic review. *British Journal of Occupational Therapy*, *84*(1), 22–41. <https://doi.org/10.1177/0308022620950975>
- Moore, M. J., & Demeyere, N. (2021). Multiverse to inform neurological research: an example using recovery outcome of neglect | medRxiv. In Press. Accessed May 5, 2021. <https://doi.org/10.1007/s00415-021-10612-8>

- Moore, M. J., Vancleef, K., Riddoch, J. M., Gillebert, C. R., & Demeyere, N. (2021). Visuospatial neglect: Recovery & functional outcome after 6 months. *Neurorehabilitation and Neural Repair*. <https://doi.org/10.1177/15459683211032977>
- Moore, M. J., Vancleef, K., Shalev, N., Husain, M., & Demeyere, N. (2019). When neglect is neglected: NIHSS observational measure lacks sensitivity in identifying post-stroke unilateral neglect. *Neurosurgery & Psychiatry*, *90*(9), 1070–1071. <https://doi.org/10.1136/jnnp-2018-319668>
- Nys, G. M. S., van Zandvoort, M. J. E., van der Worp, H. B., De Haan, E. H. F., De Kort, P. L. M., Jansen, B. P. W., & Kappelle, L. J. (2006). Early cognitive impairment predicts long-term depressive symptoms and quality of life after stroke. *Journal of the Neurological Sciences*, *247*(2), 149–156. <https://doi.org/10.1016/j.jns.2006.04.005>
- Parton, A., Malhotra, P., & Husain, M. (2004). Hemispatial neglect. *Journal of Neurology, Neurosurgery & Psychiatry*, *75*(1), 13–21.
- Ptak, R., Di Pietro, M., & Schnider, A. (2012). The neural correlates of object-centered processing in reading: A lesion study of neglect dyslexia. *Neuropsychologia*, *50*(6), 1142–1150. <https://doi.org/10.1016/j.neuropsychologia.2011.09.036>
- Puig-Pijoan, A., Giralt-Steinhauer, E., de Torres, A. Z., Borràs, R. M. M., Sánchez-Benavides, G., Escobar, G. G., Enríquez, C. P., Gómez-González, A., Ois, A., Rodríguez-Campello, A., Cuadrado-Godía, E., Jiménez-Conde, J., Peña-Casanova, J., & Roquer, J. (2018). Underdiagnosis of unilateral spatial neglect in stroke unit. *Acta Neurologica Scandinavica*, *138*(5), 441–446. <https://doi.org/10.1111/ane.12998>
- Punt, T. D., & Riddoch, M. J. (2006). Motor neglect: Implications for movement and rehabilitation following stroke. *Disability and Rehabilitation*, *28*(13-14), 857–864. <https://doi.org/10.1080/09638280500535025>
- Quinn, T. J., Langhorne, P., & Stott, D. J. (2011). Barthel Index for stroke trials. *Stroke*, *42*(4), 1146–1151. <https://doi.org/10.1161/STROKEAHA.110.598540>
- Rorden, C., & Karnath, H.-O. (2010). A simple measure of neglect severity. *Neuropsychologia*, *48*(9), 2758–2763. <https://doi.org/10.1016/j.neuropsychologia.2010.04.018>
- Stone, S., Patel, P., Greenwood, R., & Halligan, P. (1992). Measuring visual neglect in acute stroke and predicting its recovery: The visual neglect recovery index. *Journal of Neurology, Neurosurgery & Psychiatry*, *55*(6), 431–436. <https://doi.org/10.1136/jnnp.55.6.431>
- Ten Brink, A. F. T., Verwer, J. H., Biesbroek, J. M., Visser-Meily, J. M. A., & Nijboer, T. C. W. (2017). Differences between left- and right-sided neglect revisited: A large cohort study across multiple domains. *Journal of Clinical and Experimental Neuropsychology*, *39*(7), 707–723. <https://doi.org/10.1080/13803395.2016.1262333>
- Ten Brink, A. F., Biesbroek, J. M., Oort, Q., Visser-Meily, J. M. A., & Nijboer, T. C. W. (2019). Peripersonal and extrapersonal visuospatial neglect in different frames of reference: A brain lesion-symptom mapping study. *Behavioural Brain Research*, *356*, 504–515. <https://doi.org/10.1016/j.bbr.2018.06.010>
- Walker, M. F., & Lincoln, N. B. (1991). Factors influencing dressing performance after stroke. *Journal of Neurology, Neurosurgery & Psychiatry*, *54*(8), 699–701. <https://doi.org/10.1136/jnnp.54.8.699>
- Whiting, S., & Lincoln, N. (1980). An ADL assessment for stroke patients. *British Journal of Occupational Therapy*, *43*(2), 44–46. <https://doi.org/10.1177/030802268004300207>