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Clinical Short Communication

# The test accuracy of the Montreal Cognitive Assessment (MoCA) by stroke lateralisation

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ABSTRACT

*Background:* The Montreal Cognitive Assessment (MoCA) is an increasingly popular screening tool for detecting cognitive impairment post-stroke. However its' test accuracy by stroke lateralisation is as yet unknown.
*Aim:* Our aim was to investigate whether the test accuracy of the MoCA differs by stroke lateralisation across different cognitive domains.
*Methods:* We retrospectively examined the cognitive profiles of 228 subacute stroke patients (86 Left, 142 Right), comparing MoCA-total and domain-specific scores with performance on detailed neuropsychological assessment.
*Results:* The prevalence of cognitive impairment detected on neuropsychological assessment was high and relatively comparable between the right and left hemisphere stroke groups (91% and 93% respectively). Notably however, 29% of the right stroke group and 6% of the left stroke group achieved a "cognitively-intact" MoCA score (≥25). A high proportion of right stroke patients who had an overall MoCA-intact score were found to be impaired in intellectual functioning, processing speed, executive functions and non-verbal memory on neuropsychological assessment. Furthermore, a high proportion of patients who scored full-marks within a MoCA-specified domain, irrespective of their overall score, were found to have impairment on corresponding neuropsychological assessment for both stroke groups.
*Conclusions:* Particular care needs to be taken in interpreting MoCA-intact performance for right hemisphere patients due to its poor sensitivity to right hemisphere deficits. Scoring maximum points within a MoCA-specified domain also does not necessarily indicate intact cognitive functioning in that domain. Clinicians should consider supplementing their MoCA assessment with additional tools to increase the test accuracy of detecting relevant cognitive impairments post-stroke.



## 1. Introduction

In acute stroke care, the accurate and early detection of cognitive impairment is used to inform rehabilitation and discharge planning. Stroke lateralisation can lead to different patterns of cognitive deficits with equally significant impact on functional outcomes [1–3]. As such, detailed domain-specific cognitive assessments are recommended in the context of a multidisciplinary approach [4]. However, brief screening measures are sometimes used for pragmatic reasons or deemed more clinically appropriate in patients with milder events or in those who are unable to tolerate longer complex assessments. Therefore, it is important that screening measures have the breadth and accuracy to detect post-stroke cognitive impairments in order to highlight any concerns that may warrant further investigations [5]. Historically, the Mini Mental State Examination (MMSE) has been most commonly used [6]. However, recent reviews have recommended the Montreal Cognitive Assessment, MoCA [7], for stroke-based cognitive screening [5,8,9], particularly in mild to moderate strokes without significant aphasia [10]. The MoCA contains more test items assessing stroke-relevant domains and has been shown to have better sensitivity in detecting global impairment than the MMSE [11,12].

Few studies have directly compared performance on the MoCA to more detailed domain-specific neuropsychological assessment. Results so far are difficult to consolidate across studies because of variability in the case-mix, the timing of assessments and the way in which neuropsychological data was analysed. A study that assessed stroke patients at 1- or 5- year follow-up found comparable sensitivity and specificity for detecting amnestic impairments [13], whilst another study which assessed patients at a mean post-stroke interval of 24.1 days found good sensitivity but only moderate specificity for global impairments

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[14]. Similarly, in a cohort of patients with chronic aneurysmal subarachnoid haemorrhage, the MoCA was shown to have better sensitivity than the MMSE but only moderate specificity [15,16]. In a recent retrospective study examining patients with subacute ischaemic or haemorrhagic stroke, we found 77% of patients were impaired across one or more cognitive domains on neuropsychological assessment despite being classed as cognitively intact on the MoCA [17]. Notably, the majority of patients with a MoCA-intact score (≥25) had right hemisphere strokes. This provides preliminary suggestion that the MoCA may have different test accuracy depending on stroke lateralisation. Although cognitive deficits following left hemisphere stroke such as aphasia can have an obvious impact on daily functioning, less obvious cognitive deficits following right hemisphere stroke can have an equally profound impact on long-term functional outcomes [1]. Bias' against detecting deficits in patients with right hemisphere stroke compared with left hemisphere stroke have already been shown in other common stroke assessment scales such as the NIHSS [18,19]. Under-detection of cognitive deficits following right hemisphere strokes may lead to inadequacies in rehabilitation and discharge planning or bias decisions or interpretation regarding research or treatment protocols.

Examination of the MoCA's test accuracy to stroke lateralisation has been limited. A study by Cumming and colleagues [20] examined the relationship between MoCA performance and cognitive impairment 3-months post-stroke. They found no difference in the mean MoCA score between left and right hemisphere stroke patients. However, MoCA performance had greater predictive validity for global cognitive impairment for right hemisphere stroke patients compared with left hemisphere stroke patients. The authors argued that this was because the MoCA contained attention/visuospatial items that were more sensitive to right hemisphere stroke impairments. However, patients with significant language impairments were excluded from the study, likely biasing the sample. In contrast, a more recent study using a voxel-based lesion-symptom mapping (VLSM) found that poor MoCA performance at 3-months post-stroke was mainly associated with lesions in the left hemisphere [21]. The authors suggested that perhaps left hemisphere strokes are more likely to result in poorer long-term cognitive outcome. Alternatively, it may be that the MoCA is more sensitive to detecting left hemisphere stroke impairments. Indeed, it has been shown that left hemisphere stroke patients are more likely to have difficulty completing, and score lower, on the MoCA compared with right hemisphere strokes, due to the high language demands of most MoCA subtests [22,23]. Neuropsychological assessment data was not available in the study for comparison. As yet however, no study has investigated in detail whether the test accuracy of the MoCA in detecting cognitive impairment differs by stroke lateralisation, particularly across the different cognitive domains. Examination of possible lateralisation differences will help clinicians better understand and interpret MoCA findings. The aim of this study was to address this important question by comparing MoCA performance with performance on detailed neuropsychological assessment in a cohort of subacute stroke patients.

## 2. Method

A retrospective cohort study of patients admitted 24–72 h post-stroke to the Acute Stroke/Brain Injury Unit, NHNN, between January 2011 and December 2014 was examined ($n = 469$). Inclusion criteria were the availability of MoCA and neuropsychological data ($n = 262$). Exclusion criteria were patients with bilateral strokes ($n = 25$), comorbid substance misuse or severe psychiatric disorders ($n = 9$). Demographic and clinical information collected comprised of sex, age, stroke type and lateralization. All patients were assessed on the MoCA followed by a tailored neuropsychological assessment by a Clinical Neuropsychologist who was blind to the aims of the current study as a part of standard routine care. Testing lasted approximately 60–90 min in total and was generally conducted in one session unless patients were too fatigued. The neuropsychological assessment evaluated seven cognitive domains: premorbid intellectual functioning, current intellectual functioning, memory, naming, perception, information processing speed and executive function. Premorbid intellectual functioning was assessed using the National Adult Reading Test (NART) [24]. Current general intellectual functioning was assessed using the Wechsler Adult Intelligence Scale—Third Edition (WAIS-III) [25]. Verbal and visual memory functions were assessed with either the Recognition Memory Test [26] or the Doors and People test [27]. Naming skills were examined either with the Graded Naming Test [28] or the Oldfield Naming Test [29]. Perceptual functions were assessed using the Visual Object and Space Perception Battery [30]. Information processing speed was examined using one or more of the following tests: the 'O' Cancellation, Digit Copy [31], Symbol Digit Modalities Test [32] or Trail Making Test Part A [33]. Executive functions were examined using one or more of the following tests: the Stroop Test [34], Trail Making Test Part B [33], Weigl Colour Form Sorting Task [35] or Hayling and Brixton Test [36]. Standardised test administration was employed. The results were scored using published normative data adjusting for age and education where applicable. Patients were classified as intact on the MoCA if they scored ≥25 out of 30. This cut-off was chosen as it has been shown to provide the optimal sensitivity and specificity for detecting cognitive impairment in a post-stroke sample [13]. For neuropsychological assessments, performance at or below the 5th percentile on any one test were taken to indicate impairment in that respective domain. For intellectual functioning, impairment was classified as a difference of >10 points between either the Verbal or Performance IQ measure of the Wechsler Adult Intelligence Scale – Third Edition and the respective premorbid functioning score on the National Adult Reading Test.

Two analyses were conducted. First we identified the cohort of patients obtaining MoCA ≥25 by stroke lateralisation and examined their performance on neuropsychological assessment. Secondly, we identified patients obtaining flawless scores on the individual MoCA domains (e.g. naming, memory), irrespective of their overall score, and examined their performance on corresponding neuropsychological assessments. We calculated the relevant positive predictive value (PPV) and negative predictive value (NPV); see for a similar methodology Chan et al. [17]. Our study was approved by the local clinical governance and ethics committees using de-identified data collected as part of routine clinical practice.

## 3. Results

A total of two hundred and twenty-eight patients with a unilateral stroke were identified who had both MoCA and neuropsychological assessment data. Of those, 86 (38%) patients had a left hemisphere stroke and 142 (62%) had a right hemisphere stroke. There was no significant difference between the two stroke groups on age, sex, time since injury and assessment, type of stroke or estimated premorbid intellectual functioning (see Table 1). The right hemisphere stroke group had

**Table 1**
Demographic and clinical characteristics by stroke lateralisation.

| | Left ($n = 86$) | Right ($n = 142$) | Left vs right |
|---|---|---|---|
| Age in years (SD) | 67.60 (14.45) | 64.41 (14.49) | $p = 0.11$[d] |
| Sex – male/female | 55/31 | 76/66 | $p = 0.14$[e] |
| Days since injury (SD) | 13.10 (20.52) | 12.30 (15.52) | $p = 0.74$[d] |
| Infarct/Haemorrhage | 70/16 | 110/32 | $p = 0.48$[e] |
| Premorbid intellectual functioning | | | |
| NART (SD)[a] | 104 (16.22) | 106.65 (14.63) | $p = 0.45$[d] |
| Current intellectual functioning | | | |
| Verbal IQ (SD)[b] | 93.57 (19.24) | 94.98 (17.09) | $p = 0.80$[d] |
| Performance IQ (SD)[c] | 95.8 (16.51) | 84.66 (17.04) | $p = 0.07$[d] |

[a] Left, $n = 29$; right, $n = 55$.
[b] Left, $n = 14$; right, $n = 44$.
[c] Left, $n = 10$; right, $n = 35$.
[d] Independent samples $t$-test.
[e] Pearson Chi-square.