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ORIGINAL ARTICLE

The Dutch Oxford Cognitive Screen (OCS-NL): psychometric properties in Flemish stroke survivors

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Abstract

Background and purpose The Oxford Cognitive Screen is a stroke-specific screen to evaluate attention, executive functions, memory, praxis, language, and numeric cognition. It was originally validated in England for acute stroke patients. In this study, we examined the psychometric properties of the Dutch OCS (OCS-NL).

Methods A total of 193 (99 acute stroke unit, 94 rehabilitation unit) patients were included in our study. A subset of patients ($n = 128$) completed a retest with the parallel version of the OCS-NL.

Results First, we did not find evidence for a difference in prevalence of impairment between patients in the acute stroke versus rehabilitation unit on all but one of the subtests. For praxis, we observed a 14% lower prevalence of impairment in the rehabilitation than the acute stroke unit. Second, the parallel-form reliability ranged from weak to excellent across subtests. Third, in stroke patients below age 60, the OCS-NL had a 92% sensitivity relative to the MoCA, while the MoCA had a 55% sensitivity relative to the OCS-NL. Last, although left-hemispheric stroke patients performed worse on almost all MoCA subdomains, they performed similarly to right-hemispheric stroke patients on non-language domains on the OCS-NL.

Conclusions Our results suggest that the OCS-NL is a reliable cognitive screen that can be used in acute stroke and rehabilitation units. The OCS-NL may be more sensitive to detect cognitive impairment in young stroke patients and less likely to underestimate cognitive abilities in left-hemispheric stroke patients than the MoCA.

Keywords Cerebrovascular disorders · Cognitive dysfunction · Assessment · Apraxia · Aphasia · Hemispatial neglect

Introduction

The Oxford Cognitive Screen (OCS) screens for post-stroke impairments in five cognitive domains: attention and executive functions, memory, praxis, language, and numeric cognition [1]. The OCS is well-suited for patients with expressive and comprehensive language impairments [2], in contrast to other tests commonly used to screen for post-stroke cognitive impairments [3–5]. Since the release of the OCS, many language adaptations have been

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published [6–12], among which the OCS-NL, a Dutch translation and adaptation [13]. A recent principal component analysis of a large sample of Italian and UK stroke patients demonstrated that the OCS subtests load onto six components (i.e., language and arithmetic, orientation, memory, visuomotor control, spatial exploration, and executive functions[14]. In this study, we investigated the psychometric properties of the OCS-NL in Flemish stroke patients in acute stroke and rehabilitation units.

Cognitive screening in the acute stroke versus rehabilitation unit

Domain-specific cognitive screening can guide clinicians in designing a patient-tailored neuropsychological assessment battery and inform a rehabilitation program, which is especially useful in rehabilitation units. However, the original OCS was only validated in the acute stroke unit [1]. Some OCS translations have been validated including subacute and chronic patients [6, 7, 11, 12], but none of the previous studies has compared performance on the OCS between patients in an acute stroke versus rehabilitation unit. Performance on the OCS may however differ depending on the clinical setting. First of all, although cognitive impairments can persist over time [15], many patients recover to a certain extent [16] with a typical pattern of very quick recovery in the first few weeks that then slows down [16, 17]. Spontaneous recovery has been reported for several post-stroke impairments, including hemianopia [15, 18], hemispatial neglect [17, 19, 20], apraxia[21, 22], and aphasia [23]. Interestingly, recovery rates differ depending on the domain, with recovery in visual functions being quicker than recovery in abstract reasoning and language [24]. Stroke patients may also be selectively referred to rehabilitation units based on other factors (assumed to be) associated with the likelihood of recovery [25]. Thus, spontaneous recovery and selective referral may impact the prevalence and type of cognitive impairments in patients hospitalized in acute stroke versus rehabilitation units. To support the clinical use of the OCS in the subacute phase, it is thus important to compare OCS performance between hospitalized patients in different clinical settings [26].

The Oxford Cognitive Screen versus Montreal Cognitive Assessment

Domain-general screens such as the Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE) are commonly used to detect post-stroke cognitive impairment [3–5]. However, these domain-general dementia screens suffer from several issues when applied to post-stroke cognitive screening. First, expressive and comprehensive language impairments can impede the administration of these screens in stroke patients [2]. Indeed, about 20% of stroke patients is considered untestable using dementia screens [3]. Moreover, previous research has reported that left-hemispheric patients perform worse on the MoCA than right-hemispheric patients, while this contrast is not evident on other tests [2, 27]. As the MoCA requires intact language skills to complete most items, it is likely that non-language cognitive performance is systematically underestimated in left-hemispheric stroke patients.

Second, the MoCA and MMSE only provide a total summary score, and thus do not allow clinicians to disentangle domain-specific cognitive impairments [2]. In addition, although clinicians may informally interpret patient's subtest profiles on the MoCA, it has been shown that failures on individual MoCA subtests have a limited interpretability [28]. Previous OCS validation studies indeed suggested that the OCS is more sensitive to detect domain-specific cognitive impairment than the MoCA and MMSE (Demeyere et al., 2016; Mancuso et al., 2018).

The last limitation of the MoCA for post-stroke cognitive screening is the lack of age-adjusted normative data. Indeed, the MoCA cut-off has been extensively critiqued for overestimating cognitive impairment in older adults [30, 31], which can be a significant problem when testing stroke patients in a geriatric hospital setting [26]. In addition, not using age-adjusted normative data can also underestimate cognitive impairment in younger adults. Although age-adjusted norms for dementia screens are not recommended as they can decrease the ability to predict development of dementia [32], a different reasoning may need to be considered in the context of post-stroke cognitive screening. That is, rather than predicting development of dementia, the OCS aims to detect cognitive impairment that is *due to stroke*. For this reason, age-adjusted cut-offs for the OCS-NL were developed [13]. In the current study, we examined the impact of age-adjusted norms on detecting post-stroke cognitive impairment. By comparing stroke patients to their age peers, impairment on the test will represent the impact of stroke rather than a mixed impact of stroke and associated premorbid characteristics.

The current study

In the current study, we examined the prevalence of impairments on the OCS-NL in patients hospitalized in acute versus rehabilitation units. Note that patients in the acute stroke and rehabilitation units may differ from each other in many aspects (e.g., initial stroke severity, time since stroke, age). Our goal was not to evaluate the unique impact of a hospital setting, but to compare both clinical groups including their naturally occurring differences. Second, we investigated the parallel-form reliability of the OCS-NL in stroke patients, using version-specific cut-off scores [13]. Third, as the

Table 1 Patient characteristics

	Total sample ($n=193$)				Test–retest ($n=128$)			
	M	Mdn	SD	Min–max	M	Mdn	SD	Min–max
Age (years)	65	67	14	21–91	61	62	13	21–85
Formal education (years)	12	12	3.6	5–25	12	12	4	5–22
Time since stroke (days)	21	17	19	0–128	39	35	15	21–128
Handedness (L/R/U)	20/167/6				12/68/5			
Gender (F/M/U)	81/111/1				37/47/1			
Type of stroke (ischemic/hemorrhagic/probable stroke)	150/35/8				64/21/0			
Lesion lateralization (B/L/R/U)	67/57/61/8				27/30/28/0			
	Acute stroke unit ($n=99$)				Rehabilitation unit ($n=94$)			
	M	Mdn	SD	Min–Max	M	Mdn	SD	Min–Max
Age (years)	68	70	13	28–91	62	65	14	21–87
Formal education (years)	13	12	4	6–25	12	12	4	5–22
Time since stroke (days)	8	5	10	0–51	35	33	17	12–128
Handedness (L/R/U)	8/90/1				12/77/5			
Gender (F/M/U)	44/55				37/56/1			
Type of stroke (ischemic/hemorrhagic/probable stroke)	71/20/8				79/15/0			
Lesion lateralization (B/L/R/U)	35/27/29/8				32/30/32/0			

MoCA is the current gold standard for post-stroke cognitive screening in many countries, we investigated the relation of the OCS-NL with the MoCA.

Methods

Participants

Patients older than 18 years with a confirmed or possible stroke were consecutively referred for testing at three acute stroke units (University Hospitals Leuven, Hospital East-Limburg, and Ghent University Hospital) and three rehabilitation units (University Hospitals Leuven, RevArte Antwerp, and Hospital East-Limburg) in Flanders from December 2016 until May 2019 for this prospective study. There were no exclusion criteria, except that patients or their legal representatives needed to be able to provide informed consent (we had aphasia-friendly informed consent forms and patients could also draw an X to give consent), and patients needed to be able to stay awake for at least 15 min and speak Dutch. All study procedures were in accordance with the Helsinki declaration and approved by the Ethics committees of the participating hospitals (S60062, 161010ACADEM).

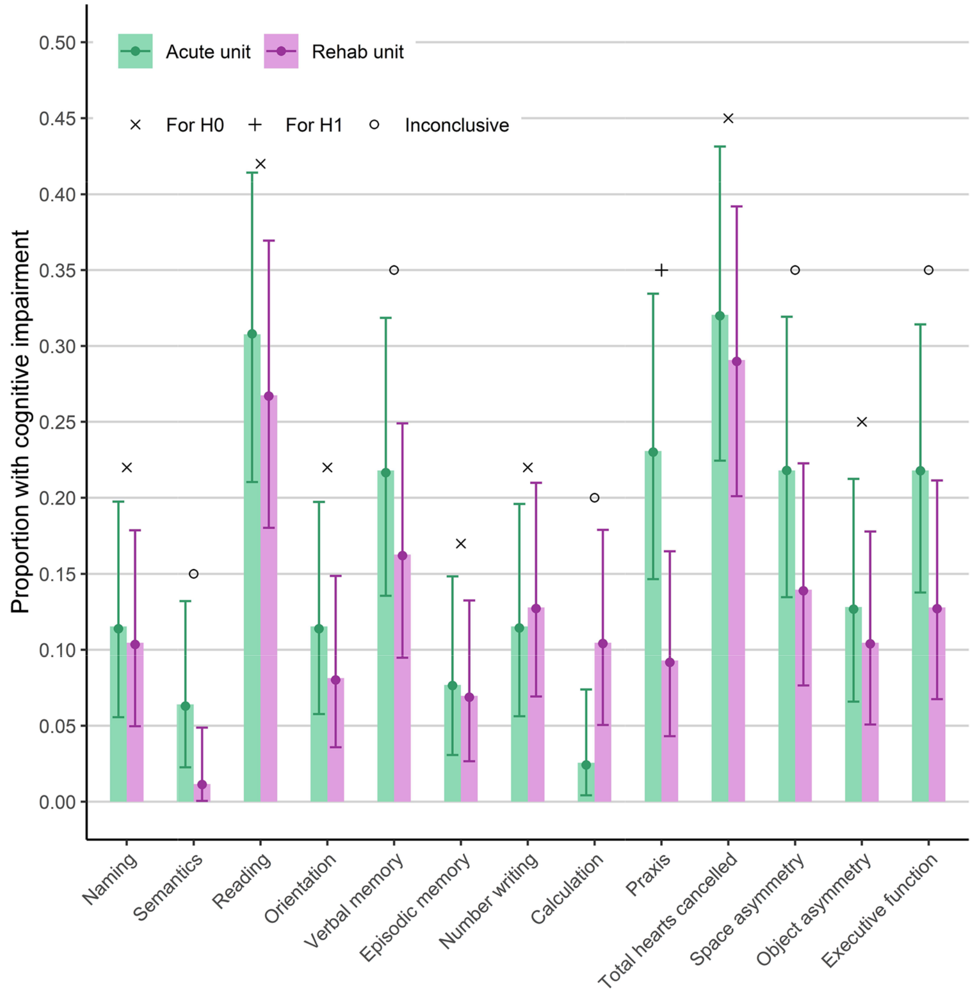
A total of 236 patients participated in this prospective study (Figure S1). Diagnosis of stroke was confirmed by neuroimaging (computed tomography (CT) in 25%, magnetic resonance imaging (MRI) in 68%) or by clinical symptomatology in 7% (i.e., probable stroke). A total of 39 patients were excluded from our analyses as stroke pathology could not be confirmed. Four other patients were excluded from the analyses as we had no information about their age, and the OCS-NL uses age-adjusted cut-offs to determine cognitive impairment [13]. A total of 193 patients were included in our analyses of which 128 completed a test–retest with the parallel form of the OCS-NL (Table 1). Of the 193 patients, 99 were tested in the acute stroke unit, and 94 in the rehabilitation unit (Table 1). The patients tested in the acute and rehabilitation units differed in age ($BF_{10}=6.9$[1]) but not in years of education ($BF_{10}=0.17$) according to Bayesian t-tests.

Neuropsychological test battery

The *Dutch version of the Oxford Cognitive Screen (OCS-NL)* screens for impairments in five domains (Table S1). Details on the development of the OCS-NL and Flemish age-adjusted normative data are available elsewhere [13]. All OCS-NL test materials are licensed at no cost to the user for publicly funded clinical or research use via Oxford University Innovations (https://innovation.ox.ac.uk/outcome-measures/the-oxford-cognitive-screen-ocs/). Instructions to download the OCS-NL are available on (http://www.neuro

[1] BF (Bayes factor) quantifies the relative strength of evidence in favor of the alternative versus null hypothesis. A $BF_{10}>3$ is considered substantial evidence in favor of the alternative hypothesis, while a $BF_{10}<0.33$ is considered substantial evidence in favor of the null hypothesis [33].

Fig. 1 Prevalence of impairments as a function of clinical setting. The bars are the observed proportions, points are the estimated proportions, and error bars are the 95% credible intervals. H0 = hypothesis that there is no difference between patients in acute stroke versus rehabilitation units; H1 = hypothesis that there is a difference between patients in acute stroke versus rehabilitation units



psychologylab.be/ocs-nl/). The Dutch version of the *MoCA* [34] *version A* was also administered.

Study design and procedure

The OCS-NL, MoCA, and a health interview were administered by a single unblinded administrator. One hundred twenty-eight patients also completed a retest with the OCS-NL parallel form in a second session. There were on average 5 days (SD = 2.9, range: 1–21) in between the administration of the two parallel versions of the OCS-NL. The order of the two OCS-NL versions alternated across patients. As the data from some recruited patients were not included in the analyses (cfr. Supra), OCS-NL version A was more often completed as the first than second test in our final sample. Of the 128 patients completing both versions, 75 patients completed version A as the first test. Of the 65 patients who completed one version, 34 patients completed version A. Although sessions were adjusted according to patients' abilities (i.e., fatigue, vigilance), not all patients completed the entire study protocol. Reasons for and predictors of missing data are reported in Supplementary Materials 3.

Results

Prevalence of cognitive impairment on the OCS-NL

The prevalence of impairments was compared between patients hospitalized in an acute stroke versus rehabilitation unit (Fig. 1, Table S3). For seven subtests, there was evidence in favor of no difference in the prevalence of impairments between patients in the acute and rehabilitation units (i.e., naming, reading, orientation, episodic memory, number writing, total hearts cancelled, and object asymmetry). For five subtests (i.e., semantics, verbal memory, calculation, space asymmetry, and executive function), the estimates suggested differences of 5 to 9% and the BF_{10} indicated inconclusive evidence for a difference (Table S3). Only for the subtest praxis, there was evidence for a difference in the prevalence of impairments between patients in the acute versus

Table 2 Correspondence between OCS-NL parallel versions A and B ($n = 128$)

Subtest	BF_{10}	Probability B impaired if A impaired			Probability B impaired if A intact			RR
		Estimate	95% Confidence Interval		*Estimate*	95% Confidence Interval		
Naming	> 100	0.80	0.56	0.94	0.05	0.02	0.10	16
Semantics	4	0.32	0.06	0.72	0.01	0.00	0.04	22
Reading	> 100	0.84	0.68	0.94	0.13	0.07	0.21	6.4
Orientation	19	0.38	0.15	0.65	0.06	0.03	0.11	6.5
Verbal memory	> 100	0.48	0.29	0.67	0.13	0.08	0.21	3.6
Episodic memory	> 100	0.74	0.44	0.93	0.06	0.02	0.11	12.7
Number writing	> 100	0.59	0.35	0.79	0.03	0.01	0.07	23
Calculation	> 100	0.56	0.25	0.83	0.05	0.02	0.10	11.6
Praxis	97	0.43	0.23	0.64	0.09	0.05	0.16	4.7
Executive function	1	0.33	0.15	0.56	0.17	0.11	0.25	1.9
Total hearts cancelled	> 100	0.84	0.70	0.94	0.13	0.07	0.21	6.5
Object asymmetry	56	0.51	0.23	0.77	0.08	0.04	0.14	6
Space asymmetry	> 100	0.48	0.30	0.67	0.12	0.07	0.20	3.9

RR risk of scoring impaired on B when impaired on A versus when not impaired on A

rehabilitation unit (Fig. 1, Table S3). Praxis impairments occurred in 14% (95% CI = [3, 25]) more patients in the acute stroke versus rehabilitation unit (Table S3).

As we noticed an overall low prevalence of cognitive impairments (Fig. 1), we additionally compared the observed prevalence rates to those of two other OCS language adaptations (Supplementary Materials 5). We found a lower prevalence of cognitive impairments on almost all subtests except for the reading task in the Flemish stroke sample compared to the English or Russian stroke samples when using cut-offs not adjusted for age (i.e., English cut-offs for the Flemish dataset).

Parallel-form reliability[2]

There was evidence in favor of a positive association between the OCS-NL parallel versions for each subtest ($BF_{10} > 3$), except for the executive function subtest ($BF_{10} = 1$) (Table 2). The relative risk ratios indicate that the probability to score impaired on OCS-NL version B was higher for patients who scored impaired on OCS-NL version A versus for patients who scored intact on OCS-NL version A (Table 2, Fig. 2). The ICC values ranged from 0.47 for the executive function subtest to 0.96 for the reading subtest and total hearts cancelled (Table S6).

Relation with the Montreal Cognitive Assessment

We contrasted cognitive impairments detected by the MoCA and OCS-NL. As the OCS-NL compares patients' test scores to age-adjusted normative data and the MoCA does not correct for age, we compared the prevalence by age groups. Age was divided into three groups, using the 33% and 66% percentiles of age. Prevalence of cognitive impairment as a function of test (OCS-NL vs MoCA) and age group was analyzed. In addition, the number of impaired subtests on the OCS-NL was compared between patients who scored impaired or intact on the MoCA per age group. Last, the subtest cognitive profiles were compared between left- and right-hemispheric stroke patients for the MoCA and OCS-NL. Details about the analyses are reported in Supplementary Materials 3.

There was an interaction between cognitive screen and age in predicting cognitive impairment (Fig. 3, Table S7). That is, for younger stroke patients, the probability of at least one impaired subtest on the OCS-NL was higher than the probability to score impaired on the MoCA, while this trend was reversed for older stroke patients (Fig. 3A). That is, for young stroke patients (< 60 years), the sensitivity of the OCS-NL relative to the MoCA was 92%, while the sensitivity of the MoCA relative to the OCS-NL was 55%. For patients aged between 60 and 69 years, the sensitivity of the OCS-NL relative to the MoCA was 87.5%, and the sensitivity of the MoCA relative to the OCS-NL was 80%. In contrast, for patients aged 70 to 91 years, the sensitivity of the OCS-NL relative to the MoCA was 68% and for the MoCA relative to the OCS-NL, 100%.

When patients scored intact on the MoCA, the average number of impaired subtests on the OCS-NL ranged from 0 to 2 (Fig. 3B). Patients aged between 26 to 59 years old with an intact MoCA score had on average 0.8 impaired subtests (SD = 0.62, range:

[2] Note that, because we retested patients only with the parallel form and not with the same form, our study does not allow to disentangle test–retest from parallel-form reliability.

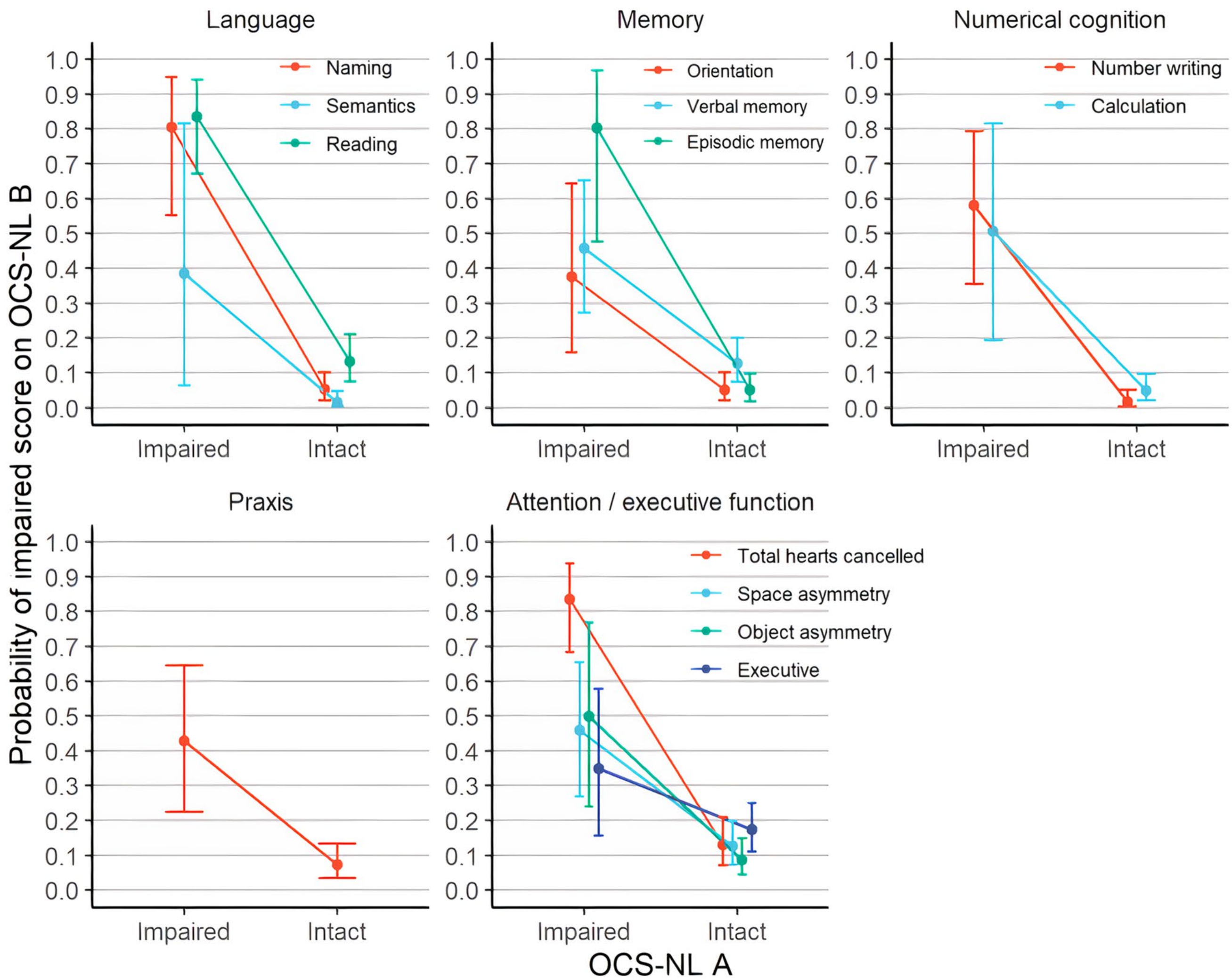


Fig. 2 Relation between OCS-NL A and OCS-NL B. The point estimates of the probability that a patient scores impaired on OCS-NL version B as a function of an impaired or intact score on OCS-NL version A is visualized. The error bars represent the 95% credible intervals

0–2). Patients aged between 60 and 69 years with an intact MoCA score had on average 0.7 impaired OCS-NL subtests (SD = 0.88, range: 0–2). All patients aged between 70 and 91 years with an intact MoCA score had zero impaired OCS-NL subtests. The total hearts cancelled subtest was the most frequently impaired subtest in patients who scored intact on the MoCA (Fig. 3C).

We also examined how subtest profiles on the MoCA and OCS-NL differed between left- and right-hemispheric stroke patients (Fig. 4, Tables S11–S12). For the MoCA, performance was worse for left-hemispheric stroke patients on every subscale, except the visuospatial subscale (Fig. 4A). For the OCS-NL, patients with left-hemispheric stroke performed worse than right-hemispheric stroke patients on tests such as naming and reading (Fig. 4B, Table S12). On many OCS-NL subtests, patients with left- and right-hemispheric stroke performed similarly on average (i.e., orientation, calculation, executive function) (Fig. 4B).

Discussion

Since clinicians may want to screen for cognitive impairments in a rehabilitation unit, it is important to establish whether the OCS is suitable to screen for cognitive impairments in this clinical setting [26]. In general, our results indicate that, even when patients are tested in a rehabilitation unit, patients still show cognitive impairments on the OCS-NL. This implies that the OCS-NL can not only be used to screen for cognitive impairments in the acute stroke unit, but also in the rehabilitation unit.

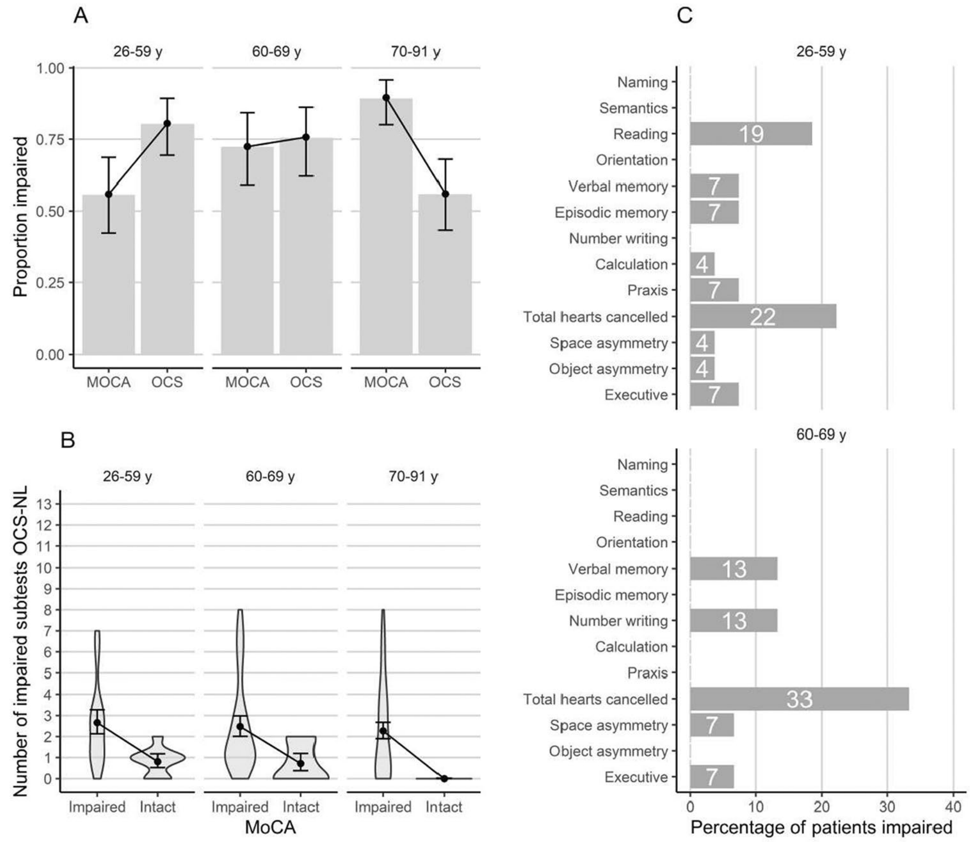


Fig. 3 Relation of OCS-NL and MoCA. In panel **A**, the proportion of impairment is shown in relation to the test and age group. The bars represent the observed proportions, error bars the 95% credible intervals. In panel **B**, the number of impaired subtests on the OCS-NL in relation to the MoCA performance is visualized. The violin represents the observed data, while the error bar represents the 95% credible intervals. In panel **C**, the percentage of patients with an impairment on each OCS-NL subtest for patients who did not have an impairment based on the MoCA are shown

In addition, we found a lower prevalence of impairments in the Flemish than the English and Russian stroke samples for most of the OCS subtests. These differences in prevalence may relate to many factors. For instance, the threestroke samples differed in demographic characteristics. In addition, stroke care, stroke severity, and the context in which testing took place (e.g., noise levels in the hospital ward) may have differed between the studies. Moreover, although the pattern of lower prevalence of impairment was consistent across the OCS subtests, it is important to note that not all OCS subtests were the same between the language adaptations. Although it is difficult to identify the cause for these differences, these results do illustrate the importance of re-assessing the psychometric properties of cognitive tests when exploring their value for new clinical settings.

Parallel-form reliability

We evaluated the parallel-form reliability of the OCS-NL. This analysis revealed that patients who scored intact on OCS-NL A had a low probability of scoring impaired on OCS-NL version B, suggesting that re-testing when patients scored intact will not have added value for clinical decisions. In contrast, when patients scored impaired on OCS-NL A, patients did not always score impaired on OCS-NL B. The latter suggests that an impaired score on the OCS-NL may best be followed up with a more extensive assessment of that cognitive domain.

In addition, one subtest showed a weak parallel-form reliability. That is, for the executive function subtest, an impairment on OCS-NL version A had no predictive power for an impairment on OCS-NL version B. The low parallel-form reliability of the executive function subtest may be related to the fact that this task involves a difference score (i.e., performance on mixed trails—performance on baseline trails), which is typically less reliable than the component scores. Indeed, similar to results from the original OCS study [1], a post hoc analysis revealed better parallel-form reliability for the mixed trails score (ICC = 0.78, 95% CI = [0.68, 0.85]) than for the difference score (ICC = 0.47, 95% CI = [0.24, 0.63]). Our results thus suggest that it may be better to use the mixed trails score in clinical practice and for future OCS adaptations. In addition, it may also be possible that executive functions fluctuate more from test to retest than other cognitive functions. Indeed, performance on attention-demanding cognitive tasks is more strongly associated with daily fluctuations in stress levels than less attention-demanding cognitive tasks [35].

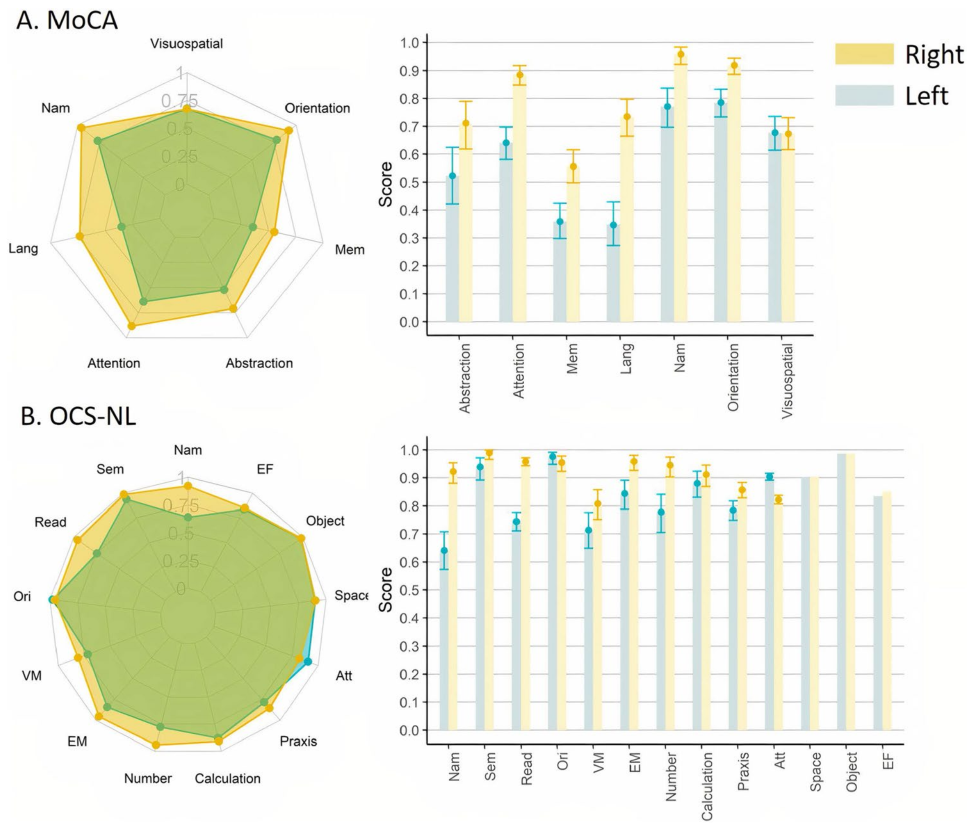


Fig. 4 Performance profiles on the MoCA and OCS-NL for patients with left- and right-lateralized stroke. Performance of each subtest was transformed to a score ranging from 0 (worst performance) to 1 (best performance). The areas on the radar plots (left side) and height of the bars (right side) are the average of this transformed score per group. Error bars are the 95% credible intervals derived from a binomial regression model (difference scores were not entered in this model). For the OCS: Nam = naming; Sem = semantics; Read = sentence reading; Ori = orientation; VM = verbal memory; EM = episodic memory; Number = number writing; VF = visual field; Att = total hearts cancelled; Space = space asymmetry; Object = object asymmetry; and EF = executive function score. For the MoCA: Mem = delayed recall; Lang = sentence repetition and verbal fluency; Nam = naming; Visuospatial = trail making, cube and clock drawing

Relation with the Montreal Cognitive Assessment

The results revealed that the OCS-NL is more likely to detect cognitive impairment in younger stroke patients (age < 60 years) than the MoCA. In contrast, the MoCA was more likely to detect cognitive impairment in older adults (age > 70 years) than the OCS-NL. This interaction with age is likely due to the use of age-adjusted cut-offs for the OCS-NL. Indeed, the MoCA cut-off has been extensively critiqued for overestimating cognitive impairment in older adults [30, 31]. Our results suggest that the OCS-NL may be more suitable than the MoCA to detect cognitive impairment in younger stroke patients. Furthermore, our results revealed that left-hemispheric stroke patients performed overall worse on the MoCA than right-hemispheric stroke patients, even on subscales that do not aim to measure typically left-lateralized functions. In contrast, in the OCS-NL left-hemispheric patients performed worse on language tests (i.e., naming, reading, verbal memory), but performed similarly to right-hemispheric stroke patients on tests that aim to measure other cognitive functions (i.e., orientation, calculation, executive functions), and performed better on the hearts cancellation test. These results suggest that the OCS-NL, in contrast to the MoCA, does not underestimate non-language cognitive performance in left-hemispheric stroke patients, consistent with the previous findings [2, 27]. One limitation of this comparison is the fact that we do not know whether the left- and right-hemispheric patients in our sample are matched on lesion volume. However, in this study, we were interested in comparing the clinical groups with their naturally occurring differences and our primary interest was not to identify the unique impact of lesion location or extent. In future research, it would be interesting to investigate whether specific lesion locations are associated to specific profiles of OCS test performance rather than merely comparing left- to right-hemispheric stroke patients.

Summary

In sum, we showed that the OCS-NL can detect post-stroke cognitive impairment in patients tested in a rehabilitation unit as well as the acute stroke unit. In addition, the parallel-form reliability of the OCS-NL varied across subtests, with most subtests showing good reliability. Last, we compared the MoCA and OCS-NL, showing that the OCS-NL is likely more sensitive to detect post-stroke cognitive impairment in younger stroke patients and less likely to underestimate cognitive function in left-hemispheric stroke patients.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10072-022-06314-2.

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Data availability The dataset accompanying this manuscript is available on: https://doi.org/10.6084/m9.figshare.17151323.v1

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval This study was ethically approved by the Ethics committees of the participating hospitals (S60062, 161010ACADEM). All study procedures were in accordance with the Helsinki declaration.

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