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RESEARCH ARTICLE

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The German version of the Oxford Cognitive Screen (D-OCS): Normative data and validation in acute stroke and a mixed neurological sample

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Abstract

Given the frequency of stroke worldwide, tools for neuropsychological assessment of patients with acute stroke are needed to identify cognitive impairments, guide rehabilitation efforts and allow for a prognosis of outcome. However, requirements for assessment tools for acute cognitive deficits differ substantially from tests for chronic neuropsychological impairments and screening tools for suspected dementia. The Oxford Cognitive Screen (OCS) has been developed as a quick to administer neurocognitive screening for acute neurological patients providing information on various cognitive domains. It is available in different languages. The present study reports cut-off scores, parallel-test reliability and concurrent validity of the German version (D-OCS). Following standardized language adaptation and translation, the D-OCS was administered to 100 healthy individuals to generate cut-off scores (5th percentile). Subsequently, 88 neurological patients were assessed with both versions of the D-OCS as well as other tests to evaluate reliability and validity of the D-OCS subscales. In a further study, the D-OCS was compared to the MoCA test in 65 acute stroke patients revealing comparable sensitivity but also differences between both tools. The cut-off scores were comparable to other international versions of the OCS. Intraclass correlations were highly significant and document reliability of the D-OCS subtests. Scores on subtests correlated significantly with independent tests securing validity. Comparison with the MoCA revealed comparable sensitivity and specificity.

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The D-OCS is a reliable and valid assessment tool well suited for patients with acute stroke. Differences to the MoCA test are discussed.

KEYWORDS

acute stroke, evaluation, neuropsychological assessment, Oxford Cognitive Screen

Key points

- The manuscript describes the subtests, reliability and validity of the German version of the Oxford Cognitive screen (D-OCS), a brief battery to assess cognition in acute stroke patients.
- Subtests were found to be highly reliable and valid in a large sample of neurological patients.
- An assessment tool is provided to assess cognition in acute stroke patients which now is available to clinicians and researchers in Germany, Austria and Switzerland.
- International multicenter studies can now investigate the neural basis of cognitive skills and evaluate interventions.

INTRODUCTION

Stroke presents the second most frequent cause of death (World Health Organization, 2020) and the main cause of disability in industrial countries (Adamson et al., 2004; World Health Organization, 2020). Every year, more than 100.000 people in the United Kingdom and more than 790.000 people in the United States suffer from stroke. About 250.000 individuals are affected in Germany (Kohler et al., 2014) with overall incidence rates varying between <1% for people aged 55 or younger and up to 8.1% for men older than 75 years (Busch & Kuhnert, 2017; Busch et al., 2013; Robert Koch-Institut, 2015). Within the next 15 years, the global burden of stroke due to death, disability and illness is expected to double but with considerable regional differences (Feigin et al., 2013).

Stroke is frequently associated with cognitive impairments affecting, among others, language processing, visual perception, spatial processing, praxis, episodic memory, attention and executive functions. Estimates of cognitive impairments after stroke range from 50% (Nys et al., 2005) to 91% (Huygelier et al., 2020; Lesniak et al., 2008). Among patients with left-hemisphere lesions, aphasia is frequent (15–30% of patients, Gottesman & Hillis, 2010). In contrast, about 40% of patients with acute right hemisphere stroke suffer from neglect (Gottesman & Hillis, 2010). In contrast to the traditional assumption (Albert, 1973; Ogden, 1985), many left hemisphere patients are affected by neglect of the right visual field with recent estimates between 20% and 35% (Beume et al., 2020; Demeyere & Gillebert, 2019). Besides these specific cortical cognitive deficits, impaired processing speed and executive functions are frequently observed in stroke patients (Cumming et al., 2013), and even at 5 years post-stroke, patients experience executive deficits and impaired information processing speed (Barker-Collo et al., 2010).

Assessment of cognitive functioning across different domains in acute stroke is relevant for designing intervention and rehabilitation efforts. At the same time, both the degree of cognitive impairment as well as affection of specific cognitive domains in acute stroke serve as prognostic factors for future autonomy, mobility and employment. For example, hemineglect and global aphasia

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are both associated with impaired autonomy and mobility (Paolucci et al., 1996), whereas executive functions in the acute phase are related to subsequent productivity (Ownsworth & Shum, 2008), and apraxia and attention deficits are associated with functional outcome after 9 months (Bickerton et al., 2015).

Many neuropsychological tests are available to assess cognitive functioning in chronic neurological patients (*cf.* Lezak et al., 2004; Strauss et al., 2006). In contrast, only few instruments are available to assess acute stroke patients. The requirements for screening tools for acute patients differ substantially from neuropsychological tools usually employed for chronic patients. The overall test for acute patients should be quicker to administer with instructions, tasks and stimuli held as simple as possible. In addition, given the frequency of neglect and aphasia, tasks need to be designed so that deficits of spatial attention, word comprehension and speech production interfere as little as possible with other domains like, for example, memory, praxis/praxia and executive functions.

Cognitive screening tools like the mini-mental state examination (MMSE; Folstein et al., 1975) or Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), although employed regularly, may be inadequate for patients with acute stroke as they are not designed to assess symptoms related to focal brain lesions (Demeyere et al., 2016; Mancuso et al., 2018; Nys et al., 2005). In addition, they provide an overall global score but little information on impaired and unimpaired performance in specific domains. Finally, these tests often provide no means to respond other than verbally, thus putting patients with impaired speech production at a disadvantage.

As an alternative, the Oxford Cognitive Screen (OCS; Demeyere et al., 2015) has been developed based on a more extensive neuropsychological test battery, the Birmingham Cognitive Screen (BCos; Humphreys et al., 2012). The OCS was developed specifically for stroke patients and, thus, incorporates subtests targeting the relevant cognitive domains including word production and comprehension, calculation, spatial attention, episodic memory, number writing, imitation of meaningless gestures and set shifting (switching). The OCS meets requirements for acute stroke patients, namely, that its administration is quick and not too demanding. Stimuli were designed so that the need to allocate spatial attention is minimized making it suitable for neglect patients. In addition, responses in several tasks can be made by pointing to different response alternatives making it possible to assess patients with aphasia. Finally, the assessment is short because several items are used for the assessment in more than one domain. For example, the subtest for neglect (Broken Hearts test) involves crossing out visual stimuli and participants have to identify these stimuli in a subsequent recognition memory task. A principal component analysis over 1973 English and Italian patients revealed six main components related to language and arithmetic, memory, spatial attention, executive functions, visuomotor skills and orientation (Iosa et al., 2022) proving the subtests' validity.

The present study reports the results of a norming study for the German version of the OCS, the D-OCS. The norming study was based on 100 unimpaired individuals. The cut-off values were determined based on the distribution of the unimpaired participants' scores. In addition, 88 and 65 neurological patients were assessed at the Department of Neurology, University Medical Center, in two studies on the reliability and validity of the D-OCS subtests and the D-OCS in comparison to the MoCA test.

METHODS

Introductory statement

All participants volunteered and gave informed consent. The study was approved by the Internal Review Board of the Medical Faculty of the University (approval no. 121/12 and 281/13). Raw data are available from the authors upon reasonable request. The study was not pre-registered.

Adaptation of the original OCS to German

The German version of the OCS, henceforth called 'D-OCS', was developed following the guidelines of the OCS publisher. Original stimuli were translated and evaluated. Backward translation by a native speaker of English, who had no knowledge of the original OCS, was checked by one author of the original OCS (N.D.). The initial evaluation of the German version revealed that two pictures for object naming of the original OCS were unsuited for German participants. The pictures of the file drawer (OCS version A) and the spanner (OCS version B) were replaced by pictures of an anchor and a harp as the file drawer is rather unusual in Germany and a spanner has too many alternative names in German. The two alternative target items had a comparable word frequency.

Like the original OCS, the D-OCS assesses picture naming with four pictures, word comprehension by asking the participant to point to three different pictures in response to a spoken word (from a total of four pictures). Orientation is evaluated by means of four questions with multiple choice response options. Reading is assessed with a sentence of 15 words containing four words whose pronunciation cannot unambiguously be inferred from its constituent letters (D-OCS version A: 'Regisseur; Serie; Kamel; Wüste'; D-OCS version B: 'Chef, Büro, Lilie, Prämie'). Subsequently, number writing (three stimuli), mental calculation (four problems), a test for spatial neglect (Broken Hearts test) and gesture imitation (two sequences of two meaningless gestures; two finger positions) are carried out followed by recognition (multiple choice) of words in the sentence and pictures and tasks presented previously. Finally, three variants of a Trail Making Test are being administered which include connecting circle, triangles and triangles and circles alternately. Like the OCS, the D-OCS offers two equivalent parallel versions to enable repeated assessment without potential training effects.

STUDY I: NORMING STUDY

Participants

The sample for the norming study consisted of 100 participants between the age of 50 and 93 years (age 50–59 years: 8; age 60–69 years: 33; age 70–79 years: 41; 80 years or older: 18 participants) without a history of neurological or psychiatric illnesses. All had normal or corrected-to-normal hearing and vision and had German as first language. Participants came from various socioeconomic backgrounds (Table 1).

TABLE 1 Demographic information for the control sample.

	n
Gender	
Female	59
Male	41
Age (years)	
Mean ± SD	71.2 ± 8.9
Range	50–92
Education	
College (>12 years total education)	40
Apprenticeship (11–12 years)	53
Middle school (9 years or less)	7

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TABLE 2 Cut-off scores for D-OCS subtests.

		D-OCS version A	D-OCS version B	D-OCS	OCS
	Max.	5th per cent	5th per cent	Final cut-off	cut-off
Picture naming	4	3	3	3	3
Semantics	3	3	3	3	3
Orientation	4	4	4	4	4
Visual field	4	4	4	4	4
Sentence reading	15	14	14	14	14
Number writing	3	3	3	3	3
Calculation	4	4	4	4	3
Hearts object asymmetry					
Upper		<−1	<−1	<−1	<0
Lower		>1	>1	>1	>0
Hearts correct	50	43	44	43	42
Hearts spatial asymmetry					
Upper		<−2	<−2	<−2	<−2
Lower		>3	>2	>3	>3
Imitation	12	9	9	8	8
Recognition 1	4	3	3	3	3
Recognition 2	4	3	3	3	3
Switching correct	13	11	11	11	7
Switching difference	−1	>1	>1	>1	>4

Procedure

Both versions of the D-OCS were administered during the same session with order of administration counter-balanced. Assessment was carried out by a research assistant trained on the D-OCS.

Results

Table 2 provides the maximum scores for each subtest as well as the 5th percentile which constitutes the cut-off value. For ease of comparison, the cut-off scores of the original OCS are provided as well (right column). The majority of the cut-off values are comparable with exception of the calculation subtest and the number of correctly marked stimuli in the switching version of the Trails test which are slightly stricter in the German D-OCS compared to the original version of the OCS.

Discussion

Overall, there is a high agreement between the two parallel versions of the D-OCS with regard to the cut-off scores. The cut-off scores for the German version also fit well with the English original values except for the calculation subtest, and the switching version of the Trails test. This is probably due to the higher educational level of the German volunteers, an issue to be discussed in the General Discussion below.

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STUDY II: VALIDATION STUDY

Participants

Between June 2018 and March 2020, 88 patients were assessed at the Department of Neurology of the University Medical Center in Freiburg, Germany (patient sample 1). Assessment included both versions of the D-OCS as well as established tests for validation of the D-OCS subtests. The sample consisted of stroke patients but also patients suffering from various neurological diseases, most notably neurodegenerative diseases. These latter patients were included if they suffered from memory deficits or 'cortical impairments' like aphasia, apraxia, acalculia, constructional or executive deficits, usually diagnosed with the CERAD test battery (Morris et al., 1988). Kaesberg et al. (2013), who had developed a test battery for patients entering neurorehabilitation, argued that attention varied too much in acute stroke patients. They, thus, chose to assess patients with dementia to study reliability for their subtests. Demographic information on the participants of the present sample can be found in Table 3. Information on etiologies can be found in Table 4.

Reliability and concurrent validity

For the parallel-test reliability, intraclass correlations (ICC, absolute agreement) were calculated. ICC vary between 0 and 1 with higher scores describing higher consistency or reliability. The score describes the consistency of two raters or test versions. For the correlations with external measures to determine concurrent validity, we calculated non-parametric Kendall's tau with the exception of the Broken Hearts test for neglect for which Pearson's correlation was calculated.

TABLE 3 Demographic information for patient sample 1.

	n
Gender	
Female	37
Male	51
Age (years)	
Mean ± SD	67.7 (±13.1)
Range	30–89

TABLE 4 Etiologies of patients of sample 1.

	n
Ischemia LH	32
Ischemia RH	22
Ischemia bilateral	3
ICH left	4
ICH right	1
ICH bilateral	1
Neurodegenerative	21
Encephalitis	3
Other	1
Total	88

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TABLE 5 Validation of D-OCS subtests.

OCS scale	Test for validation
Broken Hearts – spatial asymmetry	Star cancellation test
Switching/trails	MoCA trails
Picture naming	ACL – Picture naming
Number writing	ACL – Number writing
Calculation	KöPPS Calculation
Imitation	KöPPS Apraxia
Recognition memory	ACL – Recognition
Orientation	MoCA Orientation

To study the D-OCS subtests' concurrent validity, we compared D-OCS scores to established tests available in German (*cf.* Table 5). Picture naming and Semantics (word comprehension) were compared to the respective tests of the 'Aphasie Checkliste (ACL)' (Kalbe et al., 2002). Naming in the 'ACL' consisted of two objects, two actions and two situations to which the participants have to respond with a noun, a verb and a sentence, respectively. Comprehension in the ACL is based on word-picture matching for two different nouns, two different verbs and two different sentences. Each respective target has to be picked from four alternatives.

Number writing, calculation and imitation of gestures were compared to the respective tests of the 'Kölner neuropsychologisches Screening für Schlaganfallpatienten (KöPSS)' (Kaesberg et al., 2013). Recognition memory of the D-OCS was compared to the recognition memory test of the 'ACL'. In this test, participants view six geometric shapes for 10 s and have to recognize them about 15 min later from an array of 15 shapes.

The Broken Hearts Test (spatial asymmetry score) was validated against a calculated asymmetry score on the Star Cancellation Test (SCT): The number of correct markings in the left half of the paper was subtracted from the sum of correct markings in the right half of the paper. The Trails/Switching test was compared to the MoCA trails test. Here, the total numbers of correct connections were correlated.

Procedure

Ideally, participants completed both versions of the D-OCS and the external tests for validation. Order of the D-OCS versions as well as the external tests was counter-balanced. Reasons for incomplete administrations of the tests could be severe motor impairments affecting Number Writing, Broken Hearts and Trails subtests. In addition, since administration of all three test batteries (D-OCS A; D-OCS B; external tests) took about 45 min, a considerable number of patients completed only parts of the tests. However, order of the subtests as well as delay between tasks within each version were not compromised. The assessment took place under conditions representative for daily clinical routine, *i.e.* the participant sitting or lying on his/her bed, connected to intravenous drips and various monitors (for blood pressure, oxygen saturation and the heart rate), other persons entering or leaving the room (nurses, therapists, other patients and relatives) and spontaneous automatic measurements of blood pressure.

Results

Table 6 provides the intraclass correlation coefficients (ICCs) as a measure of reliability of the D-OCS subtests. All consistency indices were highly significant ($p < .01$), varying between .45 and .87. Table 7 provides the correlations between the D-OCS subtests and other tests of the same domain

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TABLE 6 Reliability indices (ICC) for D-OCS subtests [95% Confidence Interval, CI].

	D-OCS A versus B All patients (*N* = 88)	D-OCS A versus B Stroke patients (*n* = 67)
Picture naming	.68 (df = 69) [CI .48–.80], $p < .01$	.72 (df = 51) [CI .48–.84], $p < .01$
Number writing	.87 (df = 60) [CI .79–.92], $p < .01$	.89 (df = 42) [CI .81–.94], $p < .01$
Calculation	.80 (df = 66) [CI .69–.87], $p < .01$	.67 (df = 47) [CI .48–.80], $p < .01$
Spatial asymmetry	.61 (df = 38) [CI .37–.78], $p < .01$	.62 (df = 30) [CI .57–.80], $p < .01$
Object asymmetry	.67 (df = 37) [CI .46–.82], $p < .01$	.37 (df = 28) [CI .02–.64], $p < .05$
Imitation	.69 (df = 67) [CI .54–.80], $p < .01$	.45 (df = 50) [CI .21–.64], $p < .01$
Recognition I: verbal episodic memory	.54 (df = 61) [CI .34–.70], $p < .01$	.49 (df = 44) [CI .24–.68], $p < .01$
Recognition II: incidental episodic mem.	.46 (df = 63) [CI .24–.63], $p < .01$	.44 (df = 46) [CI .19–.65], $p < .01$
Trails switching correct	.73 (df = 45) [CI .56–.84], $p < .01$	.63 (df = 31) [CI .36–.80], $p < .01$
Trails switching difference	.62 (df = 43) [CI .40–.78], $p < .01$	.56 (df = 31) [CI .27–.76], $p < .01$

Abbreviation: df, degrees of freedom.

TABLE 7 Correlation between D-OCS subtests and external tests.

	D-OCS A versus ext.	D-OCS B versus ext.	D-OCS A versus ext.	D-OCS B versus ext.
	All patients (*N* = 88)		Stroke patients (*n* = 67)	
Picture naming (Kendall's tau-b)	.53, $p < .01$	.53, $p < .01$	.46, $p < .01$	.54, $p < .01$
Number writing (Kendall's tau-b)	.54, $p < .01$	.60, $p < .01$	.51, $p < .01$	.64, $p < .01$
Calculation (Kendall's tau-b)	.37, $p < .01$	.34, $p < .05$	n.s.	n.s.
Spatial asymmetry (Pearson)	.53, $p < .01$	.64, $p < .01$	.56, $p < .01$	.71, $p < .01$
Imitation (Kendall's tau-b)	.59, $p < .01$	.77, $p < .01$	.42, $p < .05$	.68, $p < .01$
Recognition sentence (Kendall's tau-b)	.36, $p < .01$	.42, $p < .01$	.37, $p < .05$	.73, $p < .01$
Recognition incident. (Kendall's tau-b)	.37, $p < .01$	.44, $p < .01$	.37, $p < .05$	.75, $p < .01$
Trails switching correct	.49, $p < .01$	.43, $p < .01$	.49, $p < .01$	.40, $p < .05$
Trails switching difference	−.39, $p < .01$	−.37, $p < .01$	−.43, $p < .01$	−.37, $p < .05$

as a measure of validity. Correlation varied between .37 (calculation) and .77 (gesture imitation). All correlations were highly significant with the exception of the correlation between calculation of D-OCS version B and the respective test from the KöPSS (Kaesberg et al., 2013) which was significant at the .05-level.[1]

Analyses of reliability for the stroke patients only revealed comparable indices of reliability (Table 6).[2] In the smaller sample, the correlations with the established tests for validity were significant with the exception of the calculation scores (Table 7). This will be discussed in more detail in the General Discussion section, but the smaller sample resulted in a lower statistical power. In addition, the larger

[1]We followed a reviewer's suggestion to calculate simple agreement coefficients, i.e. the proportion of patients identified as impaired or unimpaired by both test versions. These ranged from .667 (spatial asymmetry score) to .91 (semantics) with an average of 0.85.

[2]One reviewer suggested to run a principal component (PCA) like Iosa et al. (2022). A PCA over 127 patients using varimax rotation revealed four factors. Factor 1 (explaining 36% of variance) correlated most highly with naming, reading, numbers, and semantics. Factor 2, explaining additional 16% of variance, correlated with free recall and the two recognition scores. A third factor (10% of variance explained) was less specific correlating with orientation, Broken Hearts overall score, calculation, and imitation. A fourth factor (explaining 9% of variance) correlated with the asymmetry scores from the Broken Hearts test. While this seems reasonable, a larger sample, comparable to that of Iosa et al. (2022), might have revealed a more detailed set of components.

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patient sample included patients with Alzheimer's disease and Corticobasal syndrome known to suffer from parietal deficits including dyscalculia. The significant correlation in the larger sample could therefore result from the inclusion of patients with deficits in calculation.

Discussion

Reliability indices were highly significant for all subtests of the D-OCS in the whole sample and remained highly significant in the smaller group of stroke patients despite the adverse, yet representative clinical setting with several sources of distraction. With one exception, correlations of D-OCS subtests with established tests were highly significant suggesting the D-OCS subtests to reflect the integrity of the respective cognitive domain. The lower correlations for memory and calculation were, most likely, caused by differences in difficulty and procedure between the respective tests compared. This will be discussed below in the General Discussion section.

PART III: A COMPARISON OF D-OCS AND MOCA

Participants

Between March 2019 and October 2020, 65 patients from the Neurology Department were assessed with the D-OCS version A and the MoCA test (patient sample 2, Table 8). All had a first-ever stroke in the area of supply of the left or right middle cerebral artery. None had previous psychiatric or neurological complaints, all had normal or corrected-to-normal vision and hearing.

Procedure

Assessment was carried out as part of a larger test battery directed towards identifying the neural correlates of idemotor apraxia, aphasia, or neglect (e.g. Beume et al., 2020; Dressing et al., 2019). All patients were assessed by the first author with the MoCA administered before the D-OCS. Assessment, which further included Digit Span and Blocktapping tasks, took about 25 min.

Results

Impaired performance on the MoCA test was defined as a total score below 26 (Davis et al., 2021). The number of impaired scales of the D-OCS correlated significantly with the MoCA total score ($r = -.63$, $p < .01$). Table 9 provides the proportion of impaired patients on the MoCA test and the D-OCS. In our sample, both tests had a comparable sensitivity (MoCA 88%; D-OCS 90%).

TABLE 8 Demographic information for patient sample 2.

	n
Gender	
Female	25
Male	40
Age (years)	
Mean ± SD	62.4 (±13.5)
Range	30–85

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TABLE 9 Number of patients impaired on Montreal Cognitive Assessment (MoCA) test and D-OCS.

	MoCA unimpaired	MoCA impaired	Sum
D-OCS unimpaired	11	5	16
D-OCS impaired	6	43	49
Sum	17	48	65

TABLE 10 Montreal Cognitive Assessment (MoCA) profile of five patients classified as unimpaired on the D-OCS.

	MoCA total	MoCA scales
Patient 1	23	Recall 2/5, Serial 7 3/5, Trail Making, Cube copying
Patient 2	25	Recall 2/5, Trail Making, Cube copying, Clock drawing 2/3, (+1 pt.)
Patient 3	21	Recall 3/5, Digit span 1/2, Vigilance, Sentences 0/2, Abstraction 0/2, Orientation 5/6
Patient 4	22	Recall 0/5, Naming 2/3, Vigilance, Fluency, Abstraction 1/2 (+1 pt.)
Patient 5	25	Recall 4/5, Cube copying, Clock drawing 2/3, Fluency, Abstraction 0/2 (+ 1 pt.)

Of the six patients who were unimpaired on the MoCA test, two were impaired on one D-OCS subtest, two were impaired on three D-OCS subtests, while the two remaining patients were impaired on two and six subtests, respectively. The five patients which the D-OCS 'missed' to diagnose as impaired scored low on the MoCA subtests as listed in Table 10.

Discussion

This study compared performance on the D-OCS and the MoCA test in a group of 65 patients with ischemia revealing comparable sensitivity of both instruments. There was a significant correlation between the number of impaired D-OCS scales and the MoCA overall score. Both tests achieved a comparable sensitivity. However, a considerable proportion of participants in our department are unable to participate in the MoCA test due to severe language, spatial attention or motor impairments and were not included in the present analysis. These participants could, nevertheless, be assessed with individual D-OCS subtests. The D-OCS, thus, has the advantage of allowing for an assessment of individual cognitive domains even if other tests cannot be administered.

Eleven patients were impaired on only one instrument, either D-OCS or MoCA, but not the other. Of the six patients who were unimpaired on the MoCA but impaired on the D-OCS, three participants were impaired on at least three D-OCS subtests. On the other hand of the five patients which the D-OCS missed, three patients lost three points or more on the recall task. Sensitivity and specificity of free memory recall will be discussed below in greater detail. One patient suffered from an isolated short-term memory deficit (Shallice & Papagno, 2019) losing three points on the MoCA digit span forward and sentence repetition tasks. Thus, somewhat ironically, the MoCA seems better able to identify a hallmark functional syndrome of cognitive neuropsychology, the short-term memory syndrome (Shallice & Papagno, 2019). However, this makes sense if one considers one of the MoCA test's goals, namely to identify primary progressive aphasia (PPA) syndromes, including the logopenic variant PPA which is characterized by impaired repetition. Also, the D-OCS focuses less heavily on episodic memory impairments typically associated with bilateral temporal damage (typical Alzheimer's Disease; encephalitis) and less often reported for unilateral stroke.

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GENERAL DISCUSSION

The present studies describe the German version of the OCS, called D-OCS and report results of a norming and validation study. The OCS was designed to assess basic cognitive functions in acute stroke patients and has been found to serve that purpose well, especially better than other brief screening tools like MMSE or MoCA (Demeyere et al., 2016). The OCS has been translated into other languages exhibiting comparable quality and cut-off values. The current evaluation involved an assessment of 100 healthy participants to generate cut-off scores (5th percentile), a study on reliability and validity involving 88 neurological patients, as well as a comparison of the D-OCS and the MoCA test with 65 acute stroke patients.

The current norming study for the German version revealed cut-off scores comparable to other published versions of the OCS. This suggests cut-off scores to be valid across languages (Huygelier et al., 2020). The D-OCS, however, has slightly stricter cut-off values for the number of correct connections in the Trails test and Calculation, probably reflecting differences in sample composition across languages. The German participants may have been better educated since they volunteered to participate in the study.

To determine reliability and validity, 88 neurological patients were assessed repeatedly and with other tests of the domain (validation). Intraclass correlations with absolute agreement were calculated as a measure of reliability and correlations with external tests yielded estimates of validity. The intraclass correlation coefficients for the different subtests varied between .45 (Spatial Asymmetry) and .87 (Number Writing). Assessment of stroke patients was carried out as a bedside assessment under less than ideal conditions. All participants were being monitored for heart rate, blood pressure and oxygen saturation and shared rooms with other patients who received visits from nurses and relatives. Despite this distracting environment, reliability indices are comparable to other international versions of the OCS as discussed by Huygelier et al. (2020). This certainly is encouraging for researchers using other versions of the OCS.

Reliability was low for Recognition Memory II where participants have to recognize stimuli and tasks administered earlier but for which they did not receive a warning in advance. This means that during the first administration participants were unprepared that tasks and stimuli would be queried later. On the second administration, however, they expected questions on recognition to follow later and may have attempted to memorize tasks better during administration. Since the order of the two versions was counterbalanced, this created a systematic bias towards lower correlations. In addition, target items in one version of the D-OCS appeared as distractor items in the test's parallel version which may have led to interference between test versions.

The lower correlations between the D-OCS subtests and established other tests can be related to differences between tasks. For example, the memory subtests of the D-OCS were correlated with a visual recognition memory task. Here, different abstract shapes are presented in wide format putting stronger demands on spatial attention and making them more prone to neglect. Spatial attention may thus have contributed to task performance. Mental arithmetic in the KöPPS allows for multiple choice responses, but penalizes these multiple choice responses in comparison to freely produced oral responses. Therefore, patients with impaired speech production are likely to receive lower scores on calculation. However despite these differences in the design and administration of the tests, scores correlated significantly which is all the more important given fluctuating attention in the participants and the distracting environment.

In a further study, D-OCS and MoCA were compared. The number of impaired D-OCS scales correlated with the overall score on the MoCA test. In our sample of 65 acute stroke patients, sensitivity of both instruments was comparable. A previous study comparing the original OCS and the MoCA found an advantage for the OCS in comparison to the MoCA test (Demeyere et al., 2016). In the present study, participants were included who could be assessed on both the MoCA and the D-OCS. A number of patients at our department, however, could not be assessed with the MoCA but with individual D-OCS subtests making the latter better suited for acute stroke. Since critical cut-off scores are available for each D-OCS subtest, examiners can limit the assessment to those subtests which the patient is able to tackle.

With respect to those five patients which the D-OCS failed to classify as impaired but who performed below the MoCA cut-off, the free recall task of the MoCA is relevant: three of these patients lost three or more points on the delayed free recall task. Free recall, however, is considerably affected by factors unrelated to memory, including the recall strategies, attention and motivation (e.g. Brand et al., 1992; MacPherson et al., 2008). Among the 100 healthy elderly controls from Study I, 12% achieved a score of 0 or 1 (out of 4) on this task. Free recall is, therefore, a sensitive but hardly a specific task. It is conceivable that many individuals, psychiatric as well as neurological patients or individuals without a neurological condition, may fall below the MoCA total score of 26 points simply by not providing any response in the free recall task.

One other patient suffered from a rather selective impairment of verbal short-term memory. This functional syndrome consists of a selective impairment to repeat sentences and sequences of digits and has been discussed extensively in cognitive neuropsychology (e.g. Shallice & Papagno, 2019). As discussed above, the MoCA test is better able to identify disorders of repetition due to its intended application to variants of primary progressive aphasia. The D-OCS may easily be complemented by a short task of sentence repetition.

In the present sample, impaired word comprehension was rare. Participants in the present study had to provide informed consent to participate, therefore, preserved comprehension was a prerequisite for inclusion into the study. Chances are high that when applied in the clinical context, the D-OCS is able to identify impaired comprehension as, indeed, has been observed in daily clinical routine use of the D-OCS. This task, however, was not designed to be a full language comprehension task but a quick screen to ensure comprehension of very basic task instructions.

The D-OCS offers a number of advantages. First of all, versions in different languages have been published and have been shown to have comparable cut-off values allowing for easier comparison across different languages and for international multi-center studies. Second, to our knowledge, only one screening tool is available in German, the KöPPS (Kaesberg et al., 2013). This, too, offers assessment of various cognitive functions. While this collection of tests has been evaluated equally carefully, it was designed for patients entering rehabilitation units. Reliability and validity were evaluated with dementia patients and not with patients suffering from acute stroke. In addition, some cognitive deficits may interfere with tasks designed to assess unrelated cognitive functions. For example, neglect may interfere with recognition memory because visual stimuli are presented in wide format. Speech production deficits affect the score for mental calculation because multiple choice responses are awarded lower scores.

The D-OCS, like the OCS, offers assessment of both ego-centered and object-centered neglect (Demeyere & Gillebert, 2019; Moore et al., 2019) which offers the opportunity for research into the neural and cognitive correlates of object-centered neglect. Finally, evaluation of acquired dyslexia seems to be more common in Great Britain and France. German, like other European languages, has a rather transparent orthography, especially for reading, making surface dyslexia less of a focus of reading evaluation. Yet, a systematic assessment of surface dyslexia among German stroke patients is missing and despite its frequency, surface dyslexia is rarely assessed in German patients suffering from semantic dementia (Hodges et al., 1992) and Alzheimer's disease (Patterson et al., 1994). By including so-called 'exception words' in sentence reading, the D-OCS offers a brief screening tool for possible surface dyslexia (*cf.* Patterson et al., 1985) and allowing for a more systematic assessment of dyslexic syndromes in German participants.

AUTHOR CONTRIBUTIONS

Tobias Bormann: Conceptualization; formal analysis; methodology; writing–original draft; writing–review & editing. **Christoph P. Kaller**: Conceptualization; formal analysis; methodology; writing–original draft; writing–review & editing. **Caterina Kulyk**: Methodology; writing–original draft. **Nele Demeyere**: Conceptualization; methodology; writing–original draft. **Cornelius Weiller**: Conceptualization; supervision; writing–original draft; writing–review & editing.

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CONFLICT OF INTEREST STATEMENT

All other authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The votes from the Institutional Review Board did not allow for public availability of the results. Data are available from the first author upon reasonable request.

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