Psychological Assessment

# The Oxford Cognitive Screen (OCS): Validation of a Stroke-Specific Short Cognitive Screening Tool

Nele Demeyere, M. Jane Riddoch, Elitsa D. Slavkova, Wai-Ling Bickerton, and Glyn W. Humphreys

Online First Publication, March 2, 2015. http://dx.doi.org/10.1037/pas0000082

Psychological Assessment


1040-3590/15/$12.00 http://dx.doi.org/10.1037/pas0000082

# The Oxford Cognitive Screen (OCS): Validation of a Stroke-Specific Short Cognitive Screening Tool

Nele Demeyere
University of Oxford

M. Jane Riddoch and Elitsa D. Slavkova
University of Oxford

Wai-Ling Bickerton
University of Birmingham

Glyn W. Humphreys
University of Oxford

There is currently no existing freely available short screen for cognitive problems that targets stroke survivors specifically. We have developed a short cognitive screen, the Oxford Cognitive Screen (OCS), to be completed in 15–20 min, designed for use with stroke patients. To maximize inclusion, the test is aphasia- and neglect friendly and covers domains of cognition where deficits frequently occur after stroke, including apraxia and unilateral neglect as well as memory, language, executive function, and number abilities. Domain-specific scores are returned to help direct rehabilitation. This article presents the normative data in a large sample of 140 neurologically healthy participants, a report on incidences of impairments in a sample of 208 acute stroke patients (within 3 weeks of stroke onset), measures of test–retest reliability on an alternate form and convergent and divergent validity. In addition, the full test materials are made freely available for clinical use.

*Keywords:* cognitive screen, stroke, test development, validation, aphasia

*Supplemental materials:* http://dx.doi.org/10.1037/pas0000082.supp



Although incidence reports of cognitive deficits after stroke vary largely, ranging from 10% up to 91.5% of the stroke population (e.g., Jaillard, Naegele, Trabucco-Miguel, LeBas, & Hommel, 2009; Rasquin et al., 2004), it is widely accepted that there is a high occurrence of cognitive deficits. Deficits in language, spatial attention, memory, and praxis (skilled action) are prominent (Bickerton et al., 2012; Bickerton, Samson, Williamson, & Humphreys, 2011; Humphreys, Bickerton, Samson, & Riddoch, 2012). Furthermore, the presence of cognitive deficits in acute stroke have been demonstrated to be a highly important predictor of recovery (Ballard et al., 2003; Barker-Collo & Feigin, 2006; Bickerton et al., 2012; Bickerton et al., 2011; Cicerone et al., 2000; de Haan, Nys, & Van Zandvoort, 2006; Donovan et al., 2008; Edwards et al., 2006; Fang et al., 2003; Fure, Bruun Wyller, Engedal, & Thommessen, 2006; Narasimhalu et al., 2009; Nys et al., 2006; Pohjasvaara et al., 2000; Stephens et al., 2005; van Zandvoort, Kessels, Nys, de Haan, & Kappelle, 2005; Zinn et al., 2004) and cognitive problems can significantly interfere with rehabilitation (e.g., because of poor comprehension or spatial attention). In addition, cognitive deficits after stroke are associated with a reduced quality of life (Moon, Kim, Kim, Won, & Kim, 2004; Nichols-Larsen, Clark, Zeringue, Greenspan, & Blanton, 2005; Paul et al., 2005) and depression (Nys et al., 2006). The prevalence of these deficits, and their importance for outcome, means that it is critically important that problems are detected soon after the stroke so that there can be early intervention and rehabilitation targeted at the specific problem present in the patient (e.g., for poor language or memory).

The variations in the reports of cognitive problems after stroke reflect major differences in criteria used, the exact population studied and time since stroke. Critically there is no gold standard for cognitive screening in this population. Assessments vary from lengthy neuropsychological test batteries, which are often specific to a single domain of cognition (e.g., for language), and often not feasible in the acute population, to global measures of cognition that are not targeted at some of the main features of stroke (see below). In addition, even within the existing neuropsychological batteries, there is no clear evidence for choosing which test or subtests to include and typically neuropsychologists and therapists have their own preferences of tasks, dependent on test availability and familiarity. This makes it very difficult to compare across studies and hospital services.

In acute stroke units, there is a clear need for time-efficient screening tools tuned to this particular patient population. Cur-

Nele Demeyere, M. Jane Riddoch, and Elitsa D. Slavkova, Cognitive Neuropsychology Centre, Department of Experimental Psychology, University of Oxford; Wai-Ling Bickerton, School of Psychology, University of Birmingham; Glyn W. Humphreys, Cognitive Neuropsychology Centre, Department of Experimental Psychology, University of Oxford.

This work was supported by the National Institute of Health Research through a Programme development grant and the Oxford Cognitive Health Clinical Research Facility. In addition, we received funding from the Stroke Association, United Kingdom for the research. The authors thank J. Kennedy, I. Reckless, G. Pope, and P. Mathieson (OUH acute stroke unit) for patient referrals and D. Sabanis and S. Mohammed for contributions to data collection. In addition, we thank J. King Lau for the artwork in the OCS test booklet.

Correspondence concerning this article should be addressed to Nele Demeyere, Cognitive Neuropsychology Centre, Department of Experimental Psychology, University of Oxford, Oxford OX1 3UD, United Kingdom. E-mail: nele.demeyere@psy.ox.ac.uk

rently, there exists no freely available stroke-specific cognitive screen. As a consequence, more global short-form screening tools developed to detect dementia have been adopted. For example, the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), although this instrument has been noted to lack sensitivity (Blackburn, Bafadhel, Randall, & Harkness, 2013; Blake, McKinney, Treece, Lee, & Lincoln, 2002; Pendlebury, Mariz, Bull, Mehta, & Rothwell, 2012). The MOCA (Nasreddine et al., 2005) and ACE-R (Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006) are two other tools taken from studies of dementia that are more sensitive (Pendlebury et al., 2012), but they remain limited. In particular, dementia is associated with a contrasting cognitive profile to stroke. Notably, common poststroke impairments including aphasia, visual loss, spatial neglect, apraxia, and reading/writing problems are not assessed by these screening tools. Furthermore, performance on these dementia screens can be confounded by these frequently co-occurring problems. For example, all of the screens require substantial verbal abilities and aphasic patients can fail tests labeled as assessing other domains (e.g., memory) because of language impairments. Similarly, patients can fail subtests because they neglect one side of the page (e.g., in trails tests). Furthermore, the pass or fail score that the screens provide is not always meaningful because, although different cognitive domain impairments can and do co-occur, they also dissociate across patients and need to be tackled using contrasting rehabilitation procedures. For example, patients who present with memory problems, do not necessarily present with attentional problems such as hemi-spatial neglect. Moreover, patients with contrasting impairments will require different therapeutic inputs to address their problems. Treatment of a language impairment will differ from treatment of spatial neglect, for instance. Hence there is a need for easy clinical reporting at the level of the different cognitive domains so that therapy can be targeted at the affected domain. The Oxford Cognitive Screen (OCS) addresses these problems by being designed both to measure deficits that occur after stroke and to avoid confounding effects from cognitive impairments that that frequent in this patient population.

The above analysis indicates that there are several requirements that need to be addressed in any stroke-specific short cognitive screen. These requirements include the need to (a) maximize patient inclusion and to minimize confounds (e.g., from aphasia and neglect); (b) detect clinically important deficits after stroke (e.g., apraxia and neglect); and (c) incorporate reporting procedures at the level of cognitive domains. To address these needs, we (Humphreys et al., 2012) previously developed the BCoS battery for stroke patients. The BCoS was designed to be "aphasia and neglect friendly," so that patients with these deficits could be assessed and that the deficits should not impact on other measures (e.g., of executive function or memory).

The above design features of the BCoS make it an attractive tool for the assessment of cognitive problems after stroke but there is a constraint, which is that the battery takes around 1 hr to administer. The depth of the tests that can be administered in this time period may be useful for precise diagnosis of a patient's cognitive problems, but the administration time remains too long for many clinical settings, particularly where patients are at a more acute poststroke stage. Because of this constraint, we have subsequently designed the OCS—a shorter screen of cognition after stroke that still incorporates the useful design features of the BCoS test.

## The Oxford Cognitive Screen (OCS)

The OCS is structured around five cognitive domains: Attention and executive function, Language, Memory, Number processing, and Praxis. All the tests were designed to be accomplished by patients using just one hand (either the dominant or nondominant), reducing any overall impact of commonly found upper limb motor weakness. Furthermore, the tests are designed to be inclusive and unconfounded by aphasia and neglect, when (respectively) language and spatial attention are not assessed. This is achieved by using short-high frequency words, forced-choice testing procedures, vertical layouts, and multimodal presentations. In addition, tasks are designed to sample more than one problem to make test delivery time efficient. For example, the reading assessment is also used to probe memory, similarly the test of neglect samples more than one form of this disorder. This feature, along with a reduction in the numbers of tests per domain, means that OCS can be administered within 15 min. The screen can be delivered at the bedside, is easy to administer and score and can be used to sample deficits in relatively acute stroke populations.

In addition, the OCS provides a "visual snapshot" of a patient's cognitive profile, for easy domain-level interpretation in case management meetings (see Figure 1). In this study, we report data on normative performance on the OCS, on the validation of its

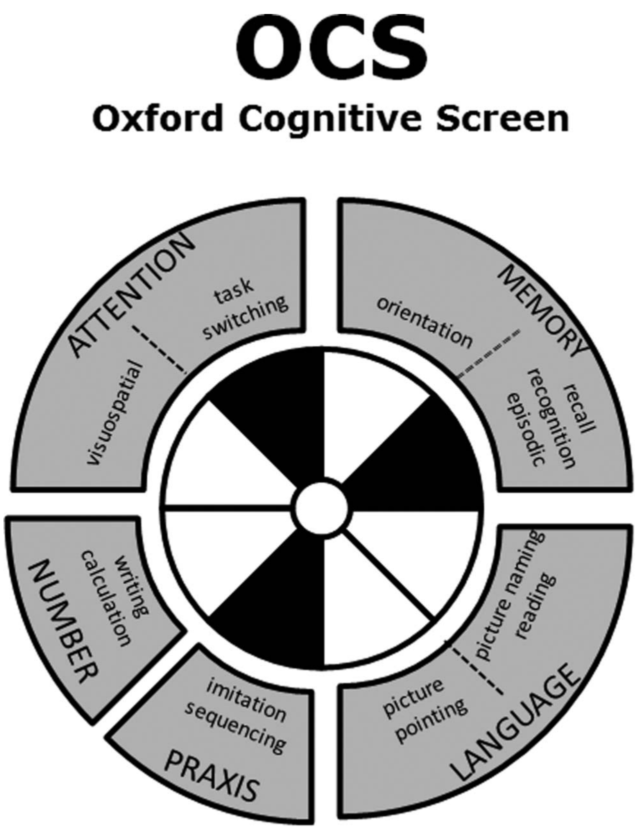


*Figure 1.* Example of a "visual snapshot" OCS cognitive profile.

subtests against other standardized assessments in the literature, on test–retest reliability using an alternate form of the test, plus also divergent and convergent validity. We also note the incidence of different profiles of deficit in an acute stroke population.

The OCS consists of 10 tasks. The order of administration is chosen to first establish a participant's level of expressive and receptive language ability, and then to assess basic orientation to time and space. Having established the level of language and general orientation, further tasks are conducted measuring aspects of memory, attention, number, praxis, and executive functioning. A full description of the 10 tasks is included in the supplementary materials.

## Scoring the Tests and Determining Impairments

To help scoring and interpretation, a separate scoring template allows the administrator to easily compare the scores recorded from one patient to the cut off values. Cut-offs are based on the normative table, given here in Table 1, but, in clinical situations, the results are presented in a more user friendly format, based on feedback from Occupational Therapists using the screen in our local hospitals (see supplementary materials).

The template (or Table 1) is used to compare a patient's subtask scores against the normative data. Most impairments arise when a patient has a lower score than the norm, though in a minority of cases tasks are impaired when the values recorded for a patient are higher than the norm cut offs. This is the case for the asymmetry values reflecting neglect, where large positive values denote left neglect and large negative values denote right neglect. Similarly, the executive score, which is calculated by subtracting the score in the set shifting condition from the sum of the single trails task scores, also indicates an impairment when the score is larger than the cut off (the larger the score, the poorer the switching performance with respect to the nonswitching trails).

## Using the Visual Snapshot Report

Once the patient's scores have been compared with the normative data, a "visual snapshot" chart (the "wheel of cognition") can be colored in, with marked areas representing impairments. There are five pieces of the wheel, each representing a cognitive domain (see Figure 1). The Memory section contains the orientation questions, verbal recall and recognition of the sentence, and the episodic recognition scores. The scores for reading the sentence and for picture naming and semantics are represented in the Language domain. Further headings are for Number and Praxis. Performance on the cancellation and executive task is represented under the heading Attention.

The snapshot report should be treated not only as a template to mark areas of impairment, but also to add comments. For example, if a patient has a problem in reading only, but not in the other language domain tasks, only part of the "domain pie" may be colored in and comments can be added in in the adjacent space next to it (e.g., "reading only impaired - score 6/15"). The report was designed to give an "at a glance" snapshot, for members of the Multi Disciplinary Team to recognize impairments, reducing the requirement to read through a long written report. Of course, the two-sided examiner sheet can also be put in the clinical notes to provide the interested party with fuller detail.

In addition to completing the template, clinical observations and comments should be added throughout; for example, if there were interruptions, or other factors that may have influenced the task score. Figure 2 illustrates how the reports are used in clinical practice.

## Method

### Materials

The OCS consists of three parts: (a) a test booklet, which can be reused for all participants, (b) a double sided examiner's page to

Table 1
*Normative Data and Cut Offs for Impairment (Scores on Subtests Lower Than 5th Centile and Higher Than 95th Centile Denote an Impairment)*

| Task name | Measure | Control sample *N* | Median score on task | Min task score | Max task score | 5th centile | 95th centile |
|---|---|---|---|---|---|---|---|
| Picture naming | Overall accuracy | 140 | 4 | 2 | 4 | 3 | |
| Semantics | Overall accuracy | 140 | 3 | 3 | 3 | 3 | |
| Orientation | Overall accuracy | 140 | 4 | 2 | 4 | 4 | |
| Visual field | Overall accuracy | 140 | 4 | 4 | 4 | 4 | |
| Sentence reading | Overall accuracy | 140 | 15 | 12 | 15 | 14 | |
| Number writing | Overall accuracy | 140 | 3 | 2 | 3 | 3 | |
| Calculation | Overall accuracy | 140 | 4 | 2 | 4 | 3 | |
| Broken hearts | Overall accuracy | 140 | 48 | 34 | 50 | 42 | |
| | Space Asym (left inattention > 0, right < 0) | 140 | 0 | −5 | 4 | −2 | 3[a] |
| | Obj Asym (left inattention > 0, right < 0) | 140 | 0 | −2 | 2 | 0[b] | 0[b] |
| Imitation | Overall accuracy | 140 | 11 | 6 | 12 | 8 | |
| Recall and recognition | Verbal recall | 115 | 2 | 0 | 4 | 0 | |
| | Verbal memory recall and recognition | 115 | 4 | 1 | 4 | 3 | |
| | Episodic recognition | 64 | 4 | 1 | 4 | 3 | |
| Executive task | Mixed | 138 | 12 | 1 | 13 | 7 | |
| | Exec score acc (sum of accuracy in single tasks versus mixed) | 138 | 0 | −3 | 9 | | 4 |

[a] For a more consistent approach: Use cut off of absolute value >2. [b] For a more conservative approach: Use cut off of 1.

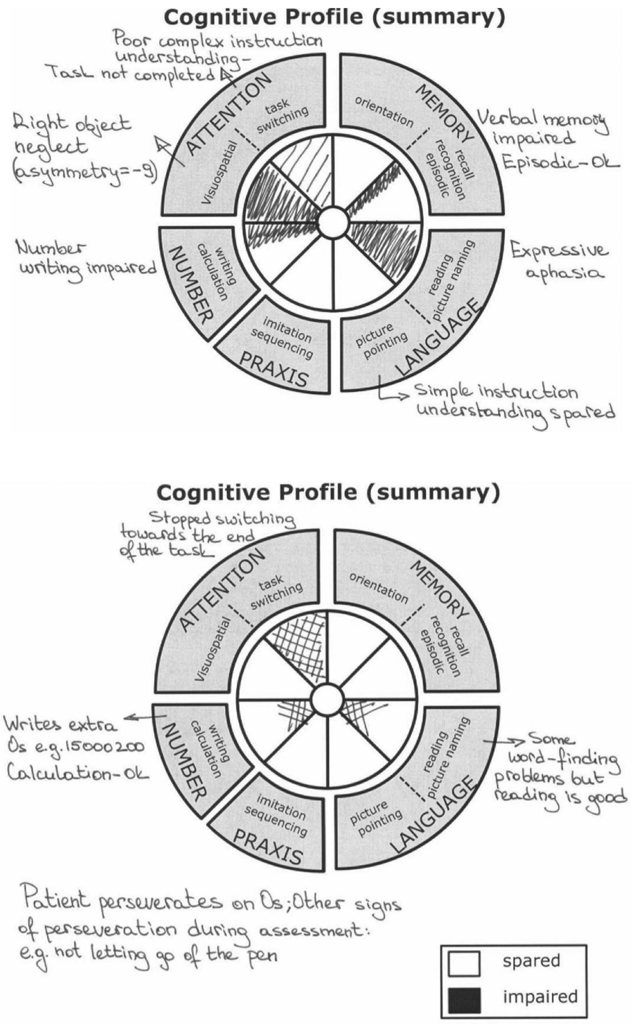


*Figure 2*. Illustration of the reports in clinical practice.

note the responses of each patient, and (3) a participant's section containing tasks for the participant to complete (writing, cancellation, and trail making). There is a written manual with clear instructions for the examiner and guides to scoring. In addition a demonstration video has been mounted online to help visualize how to position and administer the materials. These detailed manuals allow for a standardized way of delivering the assessment, therefore reducing a potential source of bias.

All test materials and the video can be found via http://isis-innovation.com/outcome-measures/the-oxford-cognitive-screen-ocs/.[1] Once familiar with the manual, the examiner's page directs the order of administration and contains instructions on test administration. Two parallel versions of the test (with different items) are designed to measure test–retest alternate form reliability.

## Participants: Neurologically Healthy Norm Sample

There were 140 neurologically healthy participants that were assessed. As some measures in the OCS evolved over time, the numbers of participants varied for some subtests (specifically the memory measures and the executive task). The participants' ages ranged from 36 to 88, with an average age of 65.0 ($SD = 12.3$). The average length of education was 13.9 years ($SD = 3.9$). There were 82 females (58.6%) and 10 left handers (7%).

## Participants: Acute Stroke Patients

We recruited a consecutive sample of 208 acute stroke patients from three sites: The acute stroke unit at the John Radcliffe hospital, Oxford and the acute stroke unit at Coventry and Warwickshire University hospitals. Patients were recruited between March 2012 and July 2013. Inclusion criteria were: patients should be within 3 weeks of confirmed stroke and be able to concentrate for 15 min (as judged by the multidisciplinary care team) and be able to give informed consent themselves (that could be witnessed in case of language difficulties or motor difficulties with signing the consent forms). The patients' ages ranged from 25 to 96, with an average age of 71.1 ($SD = 14.5$). The average length of education was 11.5 years ($SD = 2.7$). There were 94 females (45%) and 12 left handers (6%). The mean time of test was 6.6 days poststroke ($SD = 4.69$). Lesion locations for the sample were: 84 left hemisphere patients, 101 right side lesion patients, 19 bilateral, and 4 unknown (classifications from the clinical notes). Of this total sample, a first consecutive proportion additionally completed all validation tasks and the MOCA ($N = 114$), then to reduce testing times, a second consecutive sample only completed the PALPA validation task and MOCA ($N = 43$), and a third and final consecutive sample completed a retest version ($N = 53$, see below). (Note that two patients performed both the validation and the alternate form retest because of a brief overlap of Phase 2 and 3.) This way of consecutive recruiting ensures that there is no bias in selecting the patients to take part in the different parts of the study. The sample sizes for the different sections were chosen to be comparable with similar validation studies of neuropsychological assessments.

## Standard Protocol Approvals, Registrations, and Patient Consents

This study was approved by the National Research Ethics Service (REC reference 11/WM/0299; Protocol number: RP-DG-0610–10046). Written informed consent was obtained from all participants in the study.

## Test–Retest Alternate Form Reliability

Test–retest alternate form reliability was addressed by calculating intraclass correlations (ICC) between the subtest scores for two parallel versions of the OCS. ICC describes the ratio of variability between individuals to variation of observed values, taking into account individual and measurement errors. ICC values range between 0 and 1, with values closer to 1 indicating less error variance and stronger reliability. In addition, we binarized subtask performance at both Time 1 and Time 2 by impairment (above or below cut-off values) and report positive and negative predictive values. Fifty-three patients completed both versions A and B, the order of administration was random, with 32 patients completing A

[1] The OCS tests are freely available for clinical use, but to allow us to track uptake, the materials are being licensed for use through Isis Innovations.

before B and the mean time between the test and retest was 3 days (*SD* = 3.3).

## Convergent and Divergent Validity

Each subtest of the OCS was validated against an existing measure chosen to index the same underlying function (convergent validity). We report correlations and agreement rates between the diagnostic tests in terms of sensitivity and specificity. A hypothetically perfect specificity denotes that all participants rated as impaired on the validity measure are also impaired on the OCS measure (i.e., there are no false positives). A high sensitivity reflects that the task of interest is more sensitive in diagnosing an impairment (e.g., there are no false negatives when sensitivity is 100%), when compared with the standard test. An overview list of the OCS subtasks with the matched standard tasks used for the convergent validity measures is given in Table 2.

Correlations with other measures from the same domain within the OCS are also reported as further evidence for convergent validity (for those domains that have multiple subtasks). In contrast, divergent validity is demonstrated by a lack of correlation with measures that are not thought to underlie the same function. The measurement chosen for this last assessment was the Barthel index, a measure of physical activities of daily life (Mahoney & Barthel, 1965). In addition, the independence of measures will be demonstrated by reviewing the ability of OCS to differentiate between syndromes.

# Results

## Normative Data

Because of the nonnormalities in the raw score distribution and the limited score range for some tests, direct percentile conversions based on the uncorrected sample score distributions were used. Cut-off scores were set at 5th percentile (see Table 1). Aside from the normative cut off scores based on the full sample in Table 1, Table 3 provides additional information detailing average scores on the tests according to different age brackets as well as different education levels.

## Incidence in Acute Stroke

For both the validation as well as the reliability analyses, where not all patients completed both measurements, a table with the reasons for noncompletion is given in Table 4. The incidence of impairments in the acute stroke population, when compared with the control norms, is given in Table 5, both overall as well as separated by laterality of lesion. Furthermore, a description of the relative incidence of different ranges of impaired scores is provided in Table 6. Here we describe which percentages of patients were impaired at different levels. Though this is not a direct classification of severity for an individual patient, it may aid interpretation by comparing an individual patient's score to the relative incidence of this score within our acute stroke sample.

## Reliability

Data on test–retest alternate form reliability between the parallel versions of the same subtask are presented in Table 7, including intraclass correlations and positive and negative predictive values. Given the early stage of testing in our sample (average 6 days poststroke) and the time between test and retest (average 3.3 days), it is not surprising to find patients improving over time, especially within the language domain (Pedersen, Jørgensen, Nakayama, Raaschou, & Olsen, 1995), where patients' expressive speech can recover rapidly. This is reflected in the relatively low positive predictive values in a few of the subtasks (e.g., picture naming, semantics, and calculation), which are powered by a high proportion of patients who were initially impaired, but not impaired at retest on the alternate form.

Similarly, there were high negative predictive values throughout, indicative of relatively low numbers of false negatives (i.e., few people are impaired at Time 2, but not at Time 1).

## Validity

Correlations between subtests of the OCS and the validation tests are presented in Table 8 and Table 9, plus also results of the sensitivity and specificity analyses. With these we note the low

Table 2
*Overview of Measures for Convergent Validity*

| OCS subtask | Score range | Validation task | Score range |
|---|---|---|---|
| Picture naming | 0 to 4 | MOCA picture naming subtask[a] | 0 to 3 |
| Semantics | 0 to 3 | Palpa 47-spoken word picture matching[b] | 0 to 5 |
| Orientation | 0 to 4 | MOCA orientation | 0 to 6 |
| Sentence reading | 0 to 15 | BDAE reading 5 sentences[c] | 0 to 5 |
| Number writing | 0 to 3 | MOCA clock subtask | 0 to 3 |
| Calculation | 0 to 4 | CAT-MCQ calculations page[d] | 0 to 6 |
| Broken hearts | 0 to 50 | BIT star cancellation task[e] | 0 to 44 |
| Imitation | 0 to 12 | Full BCoS immitation task[f] | 0 to 12 |
| Recall and recognition | 0 to 4 | Wechsler delayed memory-story recall[g] | 0 to 15 |
| Executive task | −1 to 12 | MOCA trails subtask connections | 0 to 7 |

[a] Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). [b] Kay, J., Lesser, R., & Coltheart, M. (1992). [c] Goodglass, H., Kaplan, E., & Barresi, B. (2001). [d] Swinburn, K., Porter, G., & Howard D. (2004). [e] Wilson, B., Cockburn, J., & Halligan, P. (1987). [f] Humphreys, G. W., Bickerton, W.-L., Riddoch, M. J., & Samson, D. (2012). [g] Wechsler, D. (2009).

Table 3
*Normative Data, Average Score for Differing Levels of Years of Education, as Well as Different Age Groups*

| Task name | Measure | Overall | <65 | 65–75 | >75 | Low educ | Mid educ | High educ |
|---|---|---|---|---|---|---|---|---|
| Picture naming | Overall accuracy | 3.82 | 3.95 | 3.88 | 3.59 | 3.84 | 3.69 | 3.88 |
| Semantics | Overall accuracy | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Orientation | Overall accuracy | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Visual field | Overall accuracy | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Sentence reading | Overall accuracy | 14.85 | 14.79 | 14.90 | 14.86 | 14.71 | 14.80 | 14.95 |
| Number writing | Overall accuracy | 2.93 | 3.00 | 2.93 | 2.84 | 2.84 | 2.97 | 2.95 |
| Calculation | Overall accuracy | 3.90 | 3.93 | 3.85 | 3.89 | 3.87 | 3.91 | 3.92 |
| Broken hearts | Overall accuracy | 47.31 | 47.88 | 46.70 | 46.84 | 46.59 | 47.40 | 47.86 |
| | Space asym (left inattention $> 0$, right $< 0$) | −0.11 | −0.21 | −0.08 | 0.03 | 0.22 | −0.43 | −0.09 |
| | Obj asym (left inattention $> 0$, right $< 0$) | 0.01 | 0.03 | 0.05 | −0.03 | −0.05 | 0.03 | 0.06 |
| Imitation | Overall accuracy | 10.84 | 11.09 | 11.12 | 10.05 | 10.53 | 10.86 | 10.98 |
| Recall and recognition | Verbal recall | 2.52 | 2.72 | 2.63 | 2.24 | 2.13 | 2.57 | 2.67 |
| | Verbal memory recall and recognition | 3.72 | 3.81 | 3.73 | 3.62 | 3.61 | 3.77 | 3.78 |
| | Episodic recognition | 3.83 | 3.86 | 3.85 | 3.78 | 4.00 | 3.63 | 3.87 |
| Executive task | Mixed | 10.40 | 11.46 | 10.48 | 8.51 | 8.57 | 10.71 | 11.15 |
| | Exec score acc (double best single-mixed) | 1.36 | 0.50 | 1.48 | 2.68 | 2.73 | 1.17 | 0.79 |

*Note*. Low education is considered <10 years, mid-level = 11–14, and high-level >15.

sensitivities for the picture pointing task (semantics) as well as the calculation task. For the picture pointing task, a low sensitivity of 25%, but a very high specificity at 98.44% is reported. The semantic task is very basic and therefore the difficulty level may be too low to pick up subtle deficits in comprehension; however, in its purpose of assessing instruction comprehension, it is highly successful. Similarly, the OCS calculation test demonstrated a very high specificity at 91.1% reflecting few false positives, and a relatively low sensitivity at 45.4%. The low sensitivity reflects the lower difficulty grade of the calculations used. The calculations were purposely kept simple as the aim of the task is not to detect higher level math problems, but instead intends to check for preserved basic abilities.

Also of note is the validation of the Hearts cancellation task, of which the overall accuracy demonstrated a very high sensitivity at 94.12% (one patient showed neglect on the initial BIT star cancellation test, but had fully recovered 2 days later when performing the hearts cancellation, otherwise sensitivity would have been 100%). The data indicate that the test is highly sensitive even to subtle occurrences of neglect. In contrast there was rather low

Table 4
*Inclusion and Reasons for Not Testing on All Subtests of the OCS and the Tests Used in Validation*

| | *N* completed | Total | Visual | Motor | Comprehension | Expressive aphasia | Time | Examiner error | Fatigue | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| OCS subtest | | | | | | | | | | |
| Picture naming | 207 | 208 | 1 | | | | | | | |
| Semantics | 207 | 208 | 1 | | | | | | | |
| Orientation FR | 208 | 208 | | | | | | | | |
| Orientation MCQ | 208 | 208 | | | | | | | | |
| Visual field | 205 | 208 | 1 | | 2 | | | | | |
| Sentence reading | 193 | 208 | 4 | | | 10 | | | | 1 |
| Number 2riting | 199 | 208 | | 6 | 1 | 1 | | | | 1 |
| Calculation | 206 | 208 | | 1 | | 1 | | | | |
| Hearts cancellation | 180 | 208 | 12 | | 14 | | | | | 2 |
| Imitation | 207 | 208 | 1 | | | | | | | |
| Verbal recall | 198 | 208 | | | | 10 | | | | |
| Verbal recognition | 198 | 208 | | | | 10 | | | | |
| Episodic recognition | 91 | 92 | | | | | | | 1 | |
| Executive task | 189 | 208 | 6 | 1 | 3 | 2 | 7 | | | |
| Validation tasks | | | | | | | | | | |
| MOCA picture naming subtask | 156 | 157 | | | | 1 | | | | |
| MOCA orientation | 155 | 157 | | | | 2 | | | | |
| MOCA clock total | 154 | 157 | | 1 | 2 | | | | | |
| MOCA trails | 152 | 157 | 3 | | 2 | | | | | |
| PALPA 47-spoken word picture matching | 147 | 157 | 1 | | 4 | | 5 | | | |
| CAT calculations page | 101 | 114 | 3 | | 1 | 8 | 1 | | | |
| BDAE reading | 99 | 114 | 4 | | 1 | 8 | 2 | | | |
| BIT star cancellation | 95 | 114 | 3 | 1 | 13 | | 1 | 1 | | |
| BCoS immitation task | 104 | 114 | 1 | | 6 | | 3 | | | |
| Welchsler delayed memory | 96 | 114 | | | | 13 | 5 | | | |

Table 5
*Incidence of Impairments in a Consecutive Sample of Acute Stroke Patients (Up to 3 Weeks Post Stroke)*

| Task order | Task name | Measure | *N* overall | Incidence | Overall | LHD patients | RHD patients |
|---|---|---|---|---|---|---|---|
| 1 | Picture naming | Overall accuracy | 207 | | 42.03% | 48.81% | 35.64% |
| 2 | Semantics | Overall accuracy | 207 | | 9.18% | 11.90% | 7.92% |
| 3 | Orientation | Overall accuracy | 208 | | 24.52% | 28.57% | 21.78% |
| 4 | Visual field | Overall accuracy | 206 | | 17.48% | 15.66% | 18.81% |
| 5 | Sentence reading | Overall accuracy | 203 | | 35.96% | 50.00% | 26.00% |
| 6 | Number writing | Overall accuracy | 201 | | 39.30% | 50.00% | 30.30% |
| | Calculation | Overall accuracy | 207 | | 20.29% | 30.12% | 12.87% |
| 7 | Broken hearts | Overall accuracy | 176 | | 49.43% | 43.66% | 54.02% |
| | | Spatial asymmetry | 176 | | 38.64% | 29.58% | 47.13% |
| | | Object asymmetry | 176 | | 25.57% | 21.13% | 32.18% |
| 8 | Imitation | Overall immitation | 207 | | 21.74% | 29.76% | 13.86% |
| 9 | Recall and recognition | Verbal memory total | 206 | | 35.44% | 52.44% | 21.78% |
| | | Episodic recognition | 92 | | 23.91% | 39.02% | 11.11% |
| 10 | Executive task | Executive score (relative to baseline) | 188 | | 28.19% | 22.97% | 33.68% |

*Note*. LHD = left hemisphere damage; RHD = right hemisphere damage.

sensitivity for the object asymmetry measure compared with the overall asymmetry of the validation task. The object asymmetry task, however, measures a separate aspect of neglect (allocentric neglect) relative to the overall asymmetry measure (Bickerton et al., 2011) and to the star cancellation task. Hence the different measures of neglect should not necessarily be related, but rather the test samples different problems within a domain.

## Differentiation of Disorders

Divergent validity is demonstrated in Table 10. However, independence of measures can also be shown by demonstrating impairments in one domain, yet preserved functions in another. In our acute sample, dissociations were found across all domains. With respect to Language and Number, for example, though 14% of patients were impaired in both picture naming and calculation, 28% of patients were impaired only at picture naming and 6% of patients were impaired only in calculation. Similarly, 23% of patients were impaired in both sentence reading and number writing, though single deficits were found in 15% and 13% of patients, respectively. Dissociations were also found between Memory and Attention domains, with 9% of patients failing both the executive task and the verbal memory task, and single deficits found in 24% and 19% of patients, respectively. With respect to Praxis and Attention, 8% of patients failed both domains, 9% failed praxis only, and 31% demonstrated neglect without a praxis deficit.

Another virtue of the OCS is that it can be used to differentiate different classes of patients even within some domains. For example, the reading test can be used to diagnose both surface and neglect dyslexia; the test of visual attention (Broken Hearts) can distinguish egocentric and allocentric neglect (Bickerton et al., 2011). In the reading test, 29 (14.3%) patients presented with

Table 6
*Distribution of Impaired Scores: Incidence of Impaired Scores in Acute Sample Organized by Quartiles of Items in Each Task*

| Task name | Measure | *N* (impaired) | 0 (severe) | 1 (sev-mod) | 2 (mod-mild) | 3 (mild) |
|---|---|---|---|---|---|---|
| Picture naming | Overall accuracy | 87 | 37% | 16% | 47% | |
| Semantics | Overall accuracy | 19 | 32% | 16% | 53% | |
| Orientation | Overall accuracy | 51 | 8% | 8% | 20% | 65% |
| Visual field | Overall accuracy | 36 | 6% | 6% | 53% | 36% |
| Sentence reading | Overall accuracy | 73 | 40% | 7% | 19% | 34% |
| Number writing | Overall accuracy | 79 | 43% | 33% | 24% | |
| Calculation | Overall accuracy | 42 | 36% | 17% | 48% | |
| Broken hearts | Overall accuracy | 87 | 13% | 23% | 33% | 31% |
| | Spatial asymmetry | Categories | >12 | 9–12 | 4–8 | <4 |
| | Left neglect | 40 | 20% | 15% | 35% | 30% |
| | Right neglect | 28 | 18% | 11% | 43% | 29% |
| | Object asymmetry | Categories | >12 | 9–12 | 4–8 | <4 |
| | Left neglect | 28 | 11% | 11% | 43% | 36% |
| | Right neglect | 17 | 6% | 24% | 12% | 59% |
| Imitation | Overall immitation | | | | | |
| Recall and recognition | Verbal memory total | 73 | 29% | 36% | 36% | |
| | Episodic recognition | 22 | 9% | 36% | 55% | |
| Executive task | Executive score (relative to baseline) | 53 | 6% | 15% | 25% | 57% |

*Note*. Columns reflect either direct scores in tasks with max scores of 4, or proportions of scores in the following way: 0–1/4, 1/4–1/2, 1/2–3/4, and > 3/4 of elements in the subtask correct (note: within impaired, below cut-off values).

Table 7
*Test–Retest Alternate Form Reliability for Each Subtest of the OCS*

| Task name | N tested | ICC | Positive predictive value | Negative predictive value |
|---|---|---|---|---|
| Picture naming | 53 | .331** | 38.10% | 81.25% |
| Semantics | 53 | .776** | 57.14% | 91.30% |
| Orientation FR | 52 | .490** | — | — |
| Orientation MCQ | 52 | .623** | 62.50% | 94.59% |
| Visual field | 51 | .628** | 83.33% | 93.48% |
| Sentence reading | 52 | .735** | 72.00% | 85.19% |
| Number writing | 51 | .605** | 62.07% | 86.36% |
| Calculation | 53 | .462** | 44.44% | 97.14% |
| Broken hearts acc | 38 | .733** | 75.00% | 77.78% |
| Space asymm | 38 | .472** | 54.55% | 74.07% |
| Object asymm | 38 | .709** | 66.67% | 95.65% |
| Imitation | 51 | .575** | 57.14% | 78.38% |
| Verbal recall | 52 | .767** | no cut off | |
| Verbal recognition | 50 | .640** | 72.73% | 78.57% |
| Episodic Recognition | 49 | .601** | 56.25% | 75.76% |
| Executive task | | | | |
| mixed score | 38 | .639** | 75.00% | 97.06% |
| combined score (rel to baseline) | 38 | .547** | 90.32% | 42.86% |

surface dyslexia (they regularized the irregular words more than the normal population) and 11 (4.4%) were diagnosed with neglect dyslexia based on either misreading and/or omitting letters at the left ends of words.

With the hearts cancellation task, we found that both egocentric and allocentric neglect was present in 13.6% of patients, egocentric neglect only was present in 25% of patients and allocentric neglect without egocentric bias was present in 11.9% of patients.

## Measures of Overall Performance

Like other screens of cognition, the OCS can be used to generate an aggregated score to indicate the overall performance level. One overall measure is the total number of impaired tasks. The frequency of patients failing different numbers of subtests is depicted in Figure 3. 88% of patients failed at least one of the subtests, when compared with our normative data. The total number of impaired subtests correlated significantly with the overall MOCA score ($r = -.725$, $p < .001$).

## Inclusivity

OCS subtasks were designed to be inclusive and this is verified in the high inclusion rates (see Table 4). The OCS was designed to be completed with the participant only needing to use one hand. We found that there was no difference between the rates of impairment on the trail making task between patients using their dominant hand, versus those using their unaffected nondominant hand (30% vs. 23% impairment, respectively). For Number writing, relative impairment incidences for these 2 groups were 40% and 47% for dominant versus nondominant hand use. Most notably, however, the OCS returned scores for different cognitive domains (other than the Language domain) from patients who had expressive aphasia. If we consider patients who demonstrated expressive speech problems by selecting those who were impaired in both the picture naming and sentence reading task ($N = 46$), we found that most of these patients returned scores on all the other subtasks, and even passed a number of subtasks despite impaired expressive speech. For the OCS memory domain, all of these aphasic patients returned scores for orientation and verbal recognition memory, with 46% (21) demonstrating no impairment at orientation on forced-choice testing. Similarly, for the OCS domain of praxis, all patients returned scores, with 52% (22) not demonstrating any praxic impairment. In the number domain, all Bar 1 patient produced scores, with 44% (25) passing the multiple choice calculation test. In the attention domain, 70% (32) of the aphasic patients generated a spatial attention score on the OCS hearts cancellation task and 41% (13) had no impairment. Note that this test has more complex instructions

Table 8
*Convergent Validation: Correlations Between Performance on Subtests of the OCS and Other Measures of Cognition*

| DOMAIN | Task name | Validation task | N | R | p | Sensitivity | Specificity |
|---|---|---|---|---|---|---|---|
| LANGUAGE | Picture naming | MOCA picture naming subtask | 156 | 0.530 | <.001 | 59.32% | 72.92% |
| LANGUAGE | Semantics | Palpa 47-spoken word picture matching | 149 | 0.445 | <.001 | 27.59% | 98.31% |
| MEMORY | Orientation free | MOCA orientation | 155 | 0.702 | <.001 | 68.00% | 87.38% |
| | Orientation MCQ | MOCA orientation (impaired is < 5/6) | 155 | 0.579 | <.001 | 52.00% | 92.23% |
| LANGUAGE | Sentence reading | BDAE reading (consider imp < 4/5) | 99 | 0.678 | <.001 | 62.97% | 81.94% |
| NUMBER | Number writing | MOCA clock total (consider imp if clock < 3/3) | 154 | 0.315 | <.001 | 52.63% | 70.10% |
| | Calculation | CAT-calculations page (consider imp if calc. < 4/6) | 101 | 0.722 | <.001 | 45.45% | 91.14% |
| ATTENTION | Hearts cancellation overall | BIT star cancellation overall acc | 88 | 0.645 | <.001 | 94.12% | 69.01% |
| | Asymmetry SPACE | BIT star cancellation asymmetry | 88 | 0.705 | <.001 | 65.63% | 75.00% |
| | Asymmetry OBJECT | BIT star cancellation asymmetry | 111 | 0.412 | <.001 | 46.88% | 91.07% |
| PRAXIS | Overall immitation | Full BCoS immitation task | 104 | 0.648 | <.001 | 72.20% | 90.70% |
| MEMORY | Verbal recall | Wechsler delayed free resp unit | 96 | 0.546 | <.001 | No verbal recall cut offs | |
| | | Wechsler delayed free resp theme | 96 | 0.503 | <.001 | | |
| | Verbal recognition | Wechsler delayed MCQ | 99 | 0.441 | <.001 | No Wechsler MCQ cut offs | |
| | | Wechsler delayed free resp unit | 96 | 0.596 | <.001 | 75.00% | 73.53% |
| EXECUTIVE | Executive score | MOCA trails (/7) | 152 | −0.346 | <.001 | 66.67% | 74.19% |

*Note*. Sensitivity and specificty determined by cut offs for impairment. A convergent validity (standardized tasks).

Table 9
*Convergent Validity Within OCS*

| DOMAIN | Task name | Validation task | *N* | *R* | *p* |
|---|---|---|---|---|---|
| LANGUAGE | Picture naming | Reading | 203 | 0.511 | <.001 |
| | | Semantics | 207 | 0.335 | <.001 |
| | Semantics | Reading | | | |
| MEMORY | Orientation free | Verbal recall | 198 | 0.260 | <.001 |
| | | Verbal recognition | 206 | 0.417 | <.001 |
| | | Episodic memory | 92 | 0.256 | 0.014 |
| | Orientation MCQ | Verbal recall | 198 | 0.243 | 0.001 |
| | | Verbal recognition | 206 | 0.343 | <.001 |
| | | Episodic memory | 92 | 0.286 | 0.006 |
| | Verbal recall free response | Verbal recognition | 198 | 0.612 | <.001 |
| | | Episodic memory | 89 | 0.451 | <.001 |
| | Verbal recognition-no prompt | Episodic memory | 90 | 0.680 | <.001 |
| NUMBER | Number writing | Calculation | 201 | 0.474 | <.001 |
| ATTENTION | Broken hearts acc | Visual field | 175 | 0.294 | <.001 |
| | Executive score | Executive score | 170 | −0.281 | <.001 |

and the 14 patients who did not complete this task failed because of poor comprehension (also see Table 4). For the test of executive function (task switching), 76% (36) of the aphasic patients returned scores, and of those 69% (25) were not impaired.

# Discussion

## Scope, Validity, Sensitivity, and Specificity of the OCS

The United Kingdom national clinical guidelines for stroke care state "*On admission to hospital . . . as soon as possible: perform a full medical assessment of the person with stroke, including cognition (attention, memory, spatial awareness, apraxia, perception)*" (National Institute for Health and Care Excellence, 2013). However, there is no current existing short screen for cognitive problems that targets stroke survivors. OCS is a short screen taking about 15–20 min to administer. It is designed specifically to be inclusive for stroke patients (particularly patients with aphasia or neglect), to minimize confounds by ancillary cognitive problems (aphasia and neglect) and to measure commonly occurring problems after stroke. For example, in our sample 50.6% of the patients presented with one form of neglect (ego- or allocentric) and 21.7% were diagnosed with an apraxic deficit. Neither of these problems is detected by cognitive screens such as the MMSE, the MOCA, or the ACE-R, all of which were developed for dementia. Given that both apraxia and neglect can predict functional everyday activity in the longer term (Bickerton et al., 2012, 2011), we believe that it is important for screens of cognitive problems after stroke to measure these deficits.

In this article we report data on the reliability and validity of the OCS. We found that there was significant test–retest alternate form reliability on all subtests. The use of parallel versions has the virtue that this reduces item-specific learning, and the reliable test–retest

Table 10
*Divergent Validity*

| DOMAIN | Task name | Validation task | *N* | *R* | *p* |
|---|---|---|---|---|---|
| LANGUAGE | Picture naming | Barthel | 161 | 0.072 | 0.365 |
| LANGUAGE | Semantics | Barthel | 161 | −0.003 | 0.969 |
| MEMORY | Orientation free | Barthel | 162 | 0.031 | 0.691 |
| MEMORY | Orientation MCQ | Barthel | 162 | 0.076 | 0.335 |
| LANGUAGE | Sentence reading | Barthel | 157 | 0.035 | 0.663 |
| NUMBER | Number writing | Barthel | 159 | 0.097 | 0.226 |
| | Calculation | Barthel | 162 | 0.036 | 0.651 |
| ATTENTION | Broken hearts acc | Barthel | 140 | 0.384 | <.001 |
| PRAXIS | Imitation | Barthel | 161 | 0.042 | 0.597 |
| MEMORY | Verbal recall-no prompt | OCS visual field | 196 | 0.105 | 0.142 |
| | | OCS cancellation acc | 168 | 0.110 | 0.157 |
| | | OCS executive score | 180 | −0.138 | 0.065 |
| | | Barthel | 156 | −0.019 | 0.818 |
| | Verbal recognition-no prompt | OCS visual field | 204 | 0.106 | 0.132 |
| | | OCS cancellation acc | 175 | 0.159 | 0.036 |
| | | OCS mixed corr | 187 | 0.232 | 0.001 |
| | | OCS executive score | 187 | −0.131 | 0.074 |
| | | Barthel | 162 | −0.027 | 0.729 |
| EXECUTIVE | Executive score | OCS visual field | 186 | 0.030 | 0.683 |
| | | Barthel | 151 | −0.047 | 0.567 |

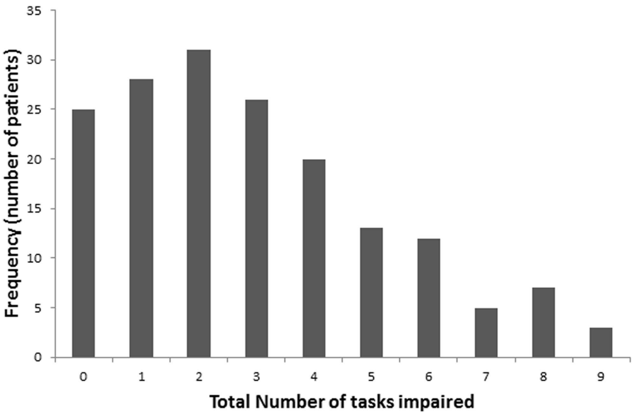


*Figure 3.* Frequency of patients failing different numbers of OCS subtests.

results across the parallel versions should give confidence that the two parallel versions do yield similar data.

The validity of the OCS was tested by comparing performance on subtests of the OCS with standard tests in the literature selected to tap the same underlying cognitive processes. Performance on subtests correlated with that on the standard tests, providing evidence for content validity. There was also generally high sensitivity, except for the more basic comprehension task (compared with a higher level semantics task), and for the calculation task. Both of these were designed to assess basic functions rather than to pick up high level deficits, and so the tests are somewhat insensitive after some recovery has taken place. Specificity was high throughout.

## Data Reporting

Performance on the OCS can be used to populate a visual snapshot of the cognitive profile of a patient, which can be used in case management. Our own clinical experience of the use of the visual snapshot with the multidisciplinary team (MDT) at our hospital has been uniformly positive and clinicians have reported both that the snapshot can be readily interpreted to highlight significant areas of weakness or strength in a patient and that it ensures that the cognitive profile of a patient is systematically reviewed in MDT meetings. The snapshot report provides a domain-level analysis that can be used to target rehabilitation. In addition to this, the OCS can be used to provide an overall measure of performance. Here we showed that an index based on the number of subtests that have been failed correlated well with the overall MOCA score and so can be used to give an overarching indication of the cognitive state of a patient.

As well as providing both overall and domain-level scores, the OCS also provides finer-grained diagnostic categories including the detection of specific types of dyslexia and different forms of unilateral neglect. We believe that this is clinically useful. We diagnosed surface dyslexia in 14% of our patients. We also found that there were dissociations between the presence of egocentric and allocentric neglect in substantial numbers of our patients. This matches prior work (Bickerton et al., 2011; Chechlacz et al., 2010; though see Rorden et al., 2012), where it has also been shown that the different forms of neglect have contrasting links to longer-term functional outcome (Bickerton et al., 2011; Chechlacz et al., 2012). In addition to these dissociations we would like to highlight the relatively high incidence of right neglect in this acute population (41% of neglect patients demonstrated right neglect). There are two points to note here. One is that the OCS is derived to be aphasia friendly, meaning that data can be collected even in aphasic patients. Often right neglect is not assessed in left hemisphere patients because of their aphasia. It is the strength of the OCS that it can be used to index right neglect even in such cases. The second is that our findings are derived from acute stroke patients (average 6 days poststroke) and it is likely that most right neglect patients show relatively rapid recovery (see also Suchan, Rorden, & Karnath, 2012) We conclude that it is important to have this differential diagnosis even at a stage of initial screening, so that rehabilitation can best be targeted at patients likely to have a longer-term problem.

## Clinical Application

Possible suggestions for clinical guidelines for application are to conduct the OCS as soon as possible after admission of a patient to an acute stroke unit to determine areas that need highlighting in the early stages of rehabilitation, as well as repeating the OCS before discharge to help inform the discharge destination and to document any improvements or worsening on cognitive domains. The more continuous measures provided by the Broken Hearts and the Trail making tasks also have the facility to demonstrate improvements, perhaps from a more severe to a milder impairment.

## Study Limitations

The normative data and cut offs for impaired scores on the OCS were based on a sample of 140 neurologically healthy controls. We recruited from a wide range of ages and education levels, and it appears from Table 3 that there is some effect of age and years of education, in particular on the executive trail making task and the sentence reading, in the normative data. However, the normative data sample here is too small to make adjustments to cut off scores for different age ranges and different education levels. To explore these effects in more detail, a larger study on neurologically healthy participants would be of great interest.

Another limitation in the OCS is the verbal recall measure, which has no normative cut off, as the 5th centile here was 0. It appears that the surprise memory task as implemented in this version of OCS may be too difficult. Therefore, in a revised version of OCS, we are recommending that examiners give individuals a clear prompt ("you will be asked to remember the words later") to highlight that participants need to remember the sentence they read and that they will be asked about it later. New normative data will be collected here and the cut off scores will be updated accordingly.

Another note concerns the applicability of the OCS beyond stroke. Although the OCS has been designed to maximize the inclusion of stroke patients and to minimize confounds by cognitive impairments outside the domain being tested, it is not meant to be limited to stroke patients. We see no reason why the OCS could not be applied to patients with other forms of neurological impairment. Indeed, we have collected data on patients in the early stages of Parkinson's disease and shown that performance on the

OCS trails provides a highly sensitive measure of nonmotor decline (Antoniades, Demeyere, Kennard, Humphreys, & Hu, in press). This offers considerable promise for the more general use of the OCS as a brief screening tool for cognitive decline.

Finally, future work will include the development of an automated testing and scoring platform. This will facilitate administration of the OCS (overcoming the current need to manage an examiner's page, a test booklet and participant pages). In addition, automated scoring and reporting would mean better standardized administration and reduced time for scoring, freeing up therapist time for rehabilitation. Ultimately, this will also enable examiner friendly applications of age and education specific cut offs.

## Conclusion

This article has presented the validity and useability of the OCS in acute stroke assessment, however, important follow on questions with regards to its precise role in planning of rehabilitation, and to what extent the acute OCS findings are able to predict levels of functional outcome, in particular activities of daily living remain. Although this is beyond the scope of the present article, we note that these are vital future questions to be addressed.

## References


Antoniades, C. A., Demeyere, N., Kennard, C., Humphreys, G. W., & Hu, M. (in press). Antisaccades and executive dysfunction in early drug–naive Parkinson's disease; the Discovery Study. *Movement Disorders*.

Ballard, C., Stephens, S., Kenny, R., Kalaria, R., Tovee, M., & O'Brien, J. (2003). Profile of neuropsychological deficits in older stroke survivors without dementia. *Dementia and Geriatric Cognitive Disorders, 16,* 52–56. http://dx.doi.org/10.1159/000069994

Barker-Collo, S., & Feigin, V. (2006). The impact of neuropsychological deficits on functional stroke outcomes. *Neuropsychology Review, 16,* 53–64. http://dx.doi.org/10.1007/s11065-006-9007-5

Bickerton, W.-L., Riddoch, M. J., Samson, D., Balani, A. B., Mistry, B., & Humphreys, G. W. (2012). Systematic assessment of apraxia and functional predictions from the Birmingham Cognitive Screen. *Journal of Neurology, Neurosurgery & Psychiatry, 83,* 513–521. http://dx.doi.org/10.1136/jnnp-2011-300968

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,* 567–580. http://dx.doi.org/10.1037/a0023501

Blackburn, D. J., Bafadhel, L., Randall, M., & Harkness, K. A. (2013). Cognitive screening in the acute stroke setting. *Age and Ageing, 42,* 113–116. http://dx.doi.org/10.1093/ageing/afs116

Blake, H., McKinney, M., Treece, K., Lee, E., & Lincoln, N. B. (2002). An evaluation of screening measures for cognitive impairment after stroke. *Age and Ageing, 31,* 451–456. http://dx.doi.org/10.1093/ageing/31.6.451

Chechlacz, M., Rotshtein, P., Bickerton, W. L., Hansen, P. C., Deb, S., & Humphreys, G. W. (2010). Separating neural correlates of allocentric and egocentric neglect: Distinct cortical sites and common white matter disconnections. *Cognitive Neuropsychology, 27,* 277–303. http://dx.doi.org/10.1080/02643294.2010.519699

Chechlacz, M., Rotshtein, P., Roberts, K. L., Bickerton, W.-L., Lau, J. K. L., & Humphreys, G. W. (2012). The prognosis of allocentric and egocentric neglect: Evidence from clinical scans. *PLoS ONE, 7,* e47821. http://dx.doi.org/10.1371/journal.pone.0047821

Cicerone, K. D., Dahlberg, C., Kalmar, K., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., . . . Morse, P. A. (2000). Evidence-based cognitive rehabilitation: Recommendations for clinical practice. *Archives of Physical Medicine and Rehabilitation, 81,* 1596–1615. http://dx.doi.org/10.1053/apmr.2000.19240

de Haan, E. H., Nys, G. M., & Van Zandvoort, M. J. (2006). Cognitive function following stroke and vascular cognitive impairment. *Current Opinion in Neurology, 19,* 559–564. http://dx.doi.org/10.1097/01.wco.0000247612.21235.d9

Donovan, N. J., Kendall, D. L., Heaton, S. C., Kwon, S., Velozo, C. A., & Duncan, P. W. (2008). Conceptualizing functional cognition in stroke. *Neurorehabilitation and Neural Repair, 22,* 122–135. http://dx.doi.org/10.1177/1545968307306239

Edwards, D. F., Hahn, M. G., Baum, C. M., Perlmutter, M. S., Sheedy, C., & Dromerick, A. W. (2006). Screening patients with stroke for rehabilitation needs: Validation of the post-stroke rehabilitation guidelines. *Neurorehabilitation and Neural Repair, 20,* 42–48. http://dx.doi.org/10.1177/1545968305283038

Fang, Y., Chen, X., Li, H., Lin, J., Huang, R., & Zeng, J. (2003). A study on additional early physiotherapy after stroke and factors affecting functional recovery. *Clinical Rehabilitation, 17,* 608–617. http://dx.doi.org/10.1191/0269215503cr655oa

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198. http://dx.doi.org/10.1016/0022-3956(75)90026-6

Fure, B., Bruun Wyller, T., Engedal, K., & Thommessen, B. (2006). Cognitive impairments in acute lacunar stroke. *Acta Neurologica Scandinavica, 114,* 17–22. http://dx.doi.org/10.1111/j.1600-0404.2006.00603.x

Goodglass, H., Kaplan, E., & Barresi, B. (2001). *Boston diagnostic aphasia examination (BDAE-3)* (3rd ed.). Austin, TX: Pro-Ed.

Humphreys, G. W., Bickerton, W. L., Samson, D., & Riddoch, M. J. (2012). *BCoS Cognitive Screen*. Hove: Psychology Press.

Jaillard, A., Naegele, B., Trabucco-Miguel, S., LeBas, J. F., & Hommel, M. (2009). Hidden dysfunctioning in subacute stroke. *Stroke, 40,* 2473–2479. http://dx.doi.org/10.1161/STROKEAHA.108.541144

Kay, J., Lesser, R., & Coltheart, M. (1992). *Psycholinguistic assessments of language processing in aphasia (PALPA)*. Hove: Psychology Press.

Mahoney, F. I., & Barthel, D. W. (1965). Functional evaluation: The Barthel Index. *Maryland State Medical Journal, 14,* 61–65.

Mathuranath, P. S., Nestor, P. J., Berrios, G. E., Rakowicz, W., & Hodges, J. R. (2000). A brief cognitive test battery to differentiate Alzheimer's disease and frontotemporal dementia. *Neurology, 55,* 1613–1620. http://dx.doi.org/10.1212/01.wnl.0000434309.85312.19

Mioshi, E., Dawson, K., Mitchell, J., Arnold, R., & Hodges, J. R. (2006). The Addenbrooke's Cognitive Examination Revised (ACE-R): A brief cognitive test battery for dementia screening. *International Journal of Geriatric Psychiatry, 21,* 1078–1085. http://dx.doi.org/10.1002/gps.1610

Moon, Y. S., Kim, S. J., Kim, H. C., Won, M. H., & Kim, D. H. (2004). Correlates of quality of life after stroke. *Journal of the Neurological Sciences, 224,* 37–41. http://dx.doi.org/10.1016/j.jns.2004.05.018

Narasimhalu, K., Ang, S., De Silva, D. A., Wong, M. C., Chang, H. M., Chia, K. S., . . . Chen, C. (2009). Severity of CIND and MCI predict incidence of dementia in an ischemic stroke cohort. *Neurology, 73,* 1866–1872. http://dx.doi.org/10.1212/WNL.0b013e3181c3fcb7

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53,* 695–699. http://dx.doi.org/10.1111/j.1532-5415.2005.53221.x

National Institute for Health and Care Excellence. (2013). *Stroke Rehabilitation: Long term rehabilitation after stroke*. CG162. London: National Institute for Health and Care Excellence. Retrieved from http://www.nice.org.uk/guidance/cg162/evidence

Nichols-Larsen, D. S., Clark, P. C., Zeringue, A., Greenspan, A., & Blanton, S. (2005). Factors influencing stroke survivors' quality of life during subacute recovery. *Stroke, 36,* 1480–1484. http://dx.doi.org/10.1161/01.STR.0000170706.13595.4f

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,* 149–156. http://dx.doi.org/10.1016/j.jns.2006.04.005

Paul, S., Sturm, J., Dewey, H., Donnan, G., Macdonell, R., & Thrift, A. (2005). Determinants of Health-related Quality of Life (HRQoL) five years after stroke in the North East Melbourne Stroke Incidence Study (NEMESIS). *Journal of the Neurological Sciences, 238,* S55. http://dx.doi.org/10.1016/S0022-510X(05)80216-3

Pedersen, P. M., Jørgensen, H. S., Nakayama, H., Raaschou, H. O., & Olsen, T. S. (1995). Aphasia in acute stroke: Incidence, determinants, and recovery. *Annals of Neurology, 38,* 659–666. http://dx.doi.org/10.1002/ana.410380416

Pendlebury, S. T., Mariz, J., Bull, L., Mehta, Z., & Rothwell, P. M. (2012). MoCA, ACE-R, and MMSE versus the National Institute of Neurological Disorders and Stroke-Canadian Stroke Network Vascular Cognitive Impairment Harmonization Standards Neuropsychological Battery after TIA and stroke. *Stroke, 43,* 464–469. http://dx.doi.org/10.1161/STROKEAHA.111.633586

Pohjasvaara, T., Mäntylä, R., Salonen, O., Aronen, H. J., Ylikoski, R., Hietanen, M., . . . Erkinjuntti, T. (2000). How complex interactions of ischemic brain infarcts, white matter lesions, and atrophy relate to poststroke dementia. *Archives of Neurology, 57,* 1295–1300. http://dx.doi.org/10.1001/archneur.57.9.1295

Ramrattan, R. S., Wolfs, R. C. W., Panda-Jonas, S., Jonas, J. B., Bakker, D., Pols, H. A., . . . de Jong, P. T. (2001). Prevalence and causes of visual field loss in the elderly and associations with impairment in daily functioning: The Rotterdam Study. *Archives of Ophthalmology, 119,* 1788–1794. http://dx.doi.org/10.1001/archopht.119.12.1788

Rasquin, S. M. C., Lodder, J., Ponds, R. W., Winkens, I., Jolles, J., & Verhey, F. R. (2004). Cognitive functioning after stroke: A one-year follow-up study. *Dementia and Geriatric Cognitive Disorders, 18,* 138–144. http://dx.doi.org/10.1159/000079193

Rorden, C., Hjaltason, H., Fillmore, P., Fridriksson, J., Kjartansson, O., Magnusdottir, S., & Karnath, H.-O. (2012). Allocentric neglect strongly associated with egocentric neglect. *Neuropsychologia, 50,* 1151–1157. http://dx.doi.org/10.1016/j.neuropsychologia.2012.03.031

Stephens, S., Kenny, R. A., Rowan, E., Kalaria, R. N., Bradbury, M., Pearce, R., . . . Ballard, C. G. (2005). Association between mild vascular cognitive impairment and impaired activities of daily living in older stroke survivors without dementia. *Journal of the American Geriatrics Society, 53,* 103–107. http://dx.doi.org/10.1111/j.1532-5415.2005.53019.x

Suchan, J., Rorden, C., & Karnath, H.-O. (2012). Neglect severity after left and right brain damage. *Neuropsychologia, 50,* 1136–1141. http://dx.doi.org/10.1016/j.neuropsychologia.2011.12.018

Swinburn, K., Porter, G., & Howard, D. (2004). *Comprehensive aphasia test*. Hove: Psychology Press.

van Zandvoort, M. J. E., Kessels, R. P. C., Nys, G. M. S., de Haan, E. H. F., & Kappelle, L. J. (2005). Early neuropsychological evaluation in patients with ischaemic stroke provides valid information. *Clinical Neurology and Neurosurgery, 107,* 385–392. http://dx.doi.org/10.1016/j.clineuro.2004.10.012

Wechsler, D. (2009). *Wechsler Memory Scale-Fourth Edition (WMS-IV) technical and interpretive manual*. San Antonio, TX: Pearson.

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

Zinn, S., Dudley, T. K., Bosworth, H. B., Hoenig, H. M., Duncan, P. W., & Horner, R. D. (2004). The effect of poststroke cognitive impairment on rehabilitation process and functional outcome. *Archives of Physical Medicine and Rehabilitation, 85,* 1084–1090. http://dx.doi.org/10.1016/j.apmr.2003.10.022

Received December 27, 2013
Revision received October 22, 2014
Accepted December 3, 2014 ■