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Short title: A Danish Version of The Oxford Cognitive Screen

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Abstract

Cognitive deficits are common following stroke and have many negative consequences. They must be identified to provide appropriate interventions and care. In Denmark, the Montreal Cognitive Assessment (MoCA), a dementia screening tool, is commonly used to screen for cognitive deficits following stroke, despite its limitations in this specific context. This study aimed to make the Oxford Cognitive Screen (OCS), a stroke-specific cognitive screening tool, available in Danish. As there are no norms available for the MoCA in Denmark, the study also aimed to evaluate the appropriateness of the MoCA cut-off of 25/26 currently used. A sample of healthy Danish participants aged 36-89 were assessed using the Danish OCS and MoCA. Mean performance and 5th percentile cut-offs were calculated for each of these tests. OCS results were similar to those from European studies. For the MoCA, 5th percentile corresponded to 22.35, suggesting that the cut-off currently used in Denmark is unsuitable.

Keywords: Oxford Cognitive Screen; cognitive assessment; cognitive screening; stroke; Montreal Cognitive Assessment; norms

Introduction

In Denmark, approximately 15,000 people suffer a stroke annually (Sundhedsstyrelsen, 2015). International incidence reports of cognitive deficits following stroke vary greatly in the literature. In a study assessing patients approximately two weeks after injury with a neuropsychological test battery, 91.5% of patients had a deficit in at least one cognitive domain (Jaillard, Naegele, Trabucco-Miguel, LeBas, & Hommel, 2009). At three months post-stroke, reported rates of post stroke dementia vary between studies from 6% to more than 30% (Sarah T. Pendlebury & Rothwell, 2009). Differences in methodological approaches, as well as demographic and stroke characteristics likely contribute to the large variation between these estimates. Common cognitive deficits seen following stroke include neglect, aphasia, apraxia as well as impairments in executive functions, memory, attention and visual perception/construction (Jaillard et al., 2009; Leśniak, Bak, Czepiel, Seniów, & Członkowska, 2008; Nys et al., 2007; Rasquin et al., 2004).

Cognitive deficits following stroke are known to have negative consequences on quality of life, chances of returning to work and likelihood of developing depressive symptoms (Hommel, Miguel, Naegele, Gonnet, & Jaillard, 2009; Nichols-Larsen, Clark, Zeringue, Greenspan, & Blanton, 2005; Nys et al., 2006; Pedersen, Jorgensen, Nakayama, Raaschou, & Olsen, 1996). The adverse effects on long-term functional outcome (Patel, Coshall, Rudd, & Wolfe, 2002; Tatemichi et al., 1994) lead to higher caregiver burden and to higher societal costs. From a clinical point of view, identifying cognitive deficits is important for providing appropriate interventions and care. As cognitive deficits can be subtle and thus easily overseen, direct screening can be useful.

There is no international gold standard for screening cognitive deficits following stroke. Assessment approaches vary from the use of very short screening tools, not originally designed for a stroke population, to the use of combinations of different neuropsychological tests of specific cognitive functions that are very time-consuming. Lengthy testing is rarely possible in the acute phase, as patients suffer from high levels of fatigue, and because of financial costs. Internationally, the short screening tools most widely used in stroke patients are the Mini Mental Status Examination (MMSE; Folstein et al., 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) (Burton & Tyson, 2015; S. T. Pendlebury, Cuthbertson, Welch, Mehta, & Rothwell, 2010). These tools are quick to administer and easy to use. However, as they are designed for dementia screening, they suffer from various limitations in a stroke context. They focus highly on cognitive functions, such as memory, language and visual construction, which are particularly relevant for dementia but fail to screen for other cognitive functions commonly affected following stroke such as neglect and visual perception. Also, by providing only a single score, these tools fail to supply information about the individual cognitive domains. This is an important limitation in a stroke context in which highly selective cognitive deficits are common. Another limitation of dementia screening tools is that aphasia and neglect - common following stroke - can contaminate performance throughout these tests (Pasi, Salvadori, Poggesi, Inzitari, & Pantoni, 2013).

According to the Danish Stroke Society (Dansk Selskab for Apopleksi), cognitive functions should be assessed at the first evaluation made by the occupational therapist or physiotherapist (Dansk Selskab for Apopleksi, 2013). Despite the limitations listed above, the MoCA is often used in this context. There is a recognised need for a screening tool that is specifically designed to identify clinically important cognitive deficits following stroke. The Oxford Cognitive Screen (OCS; Demeyere et al., 2015) is a tool that has been designed specifically for this purpose and therefore overcomes many of the limitations of the dementia screening tools described above. The OCS was designed to maximise patient inclusion and can be used in the relatively acute phase after stroke (depending on severity, as early as the same day, or as soon as the patient is able to interact for the duration of the test). It enables the assessment of the cognitive functions commonly affected by stroke and, as administration time is only 15-20 minutes, it can be completed by patients suffering from severe fatigue. In contrast to the dementia screening tool described above, the OCS evaluates post-stroke cognition at the level of cognitive domains (Attention and Executive function, Language, Memory, Number processing, and Praxis). The tool can be used at bedside and requires the use of only one hand (patients with hemiparesis can thus participate). An additional advantage of the tool is that it provides a “visual snapshot” (Figure 1) of the cognitive profile that can be used to facilitate communication of results between health care professionals, the patient and caregivers. The original British validation study provided evidence of content validity for the OCS, and the test displayed a high level of specificity (Demeyere et al., 2015).

The features described above make the OCS an attractive tool for cognitive screening of stroke patients in the acute phase (Demeyere et al., 2015, 2016). Normative data are available for the original English version (Demeyere et al., 2015), a Cantonese version (Kong et al., 2016), an Italian version (Mancuso et al., 2016), and a Russian version (Shendyapina et al, in press). Further translations are under way.

[Figure 1 about here]

The core aim of the current study was to make the OCS available in Danish, providing a new alternative for cognitive screening following stroke in a Danish context. An additional aim of the study was to evaluate the appropriateness of the MoCA cut-off that is currently used in Denmark. Although the MoCA is commonly used, there are currently no local norms available for the test. Therefore, health care professionals typically use the 25/26 cut-off provided in the original Canadian validations study (Nasreddine et al., 2005), despite little being known about its appropriateness in a Danish context.

Method

Procedure

The OCS was translated to Danish. A group of healthy Danish participants were assessed with the Danish version of the OCS (OCS-Dansk) followed by the 7.0 version of the MoCA (Danish translation by Kirsten Abelskov) (Nasreddine et al., 2005) in the same session. Cut-offs were calculated for both tests and compared to cut-offs provided in international studies.

Materials

The OCS includes the following material: A manual, a stimulus book, a scoring sheet and stimulus material. It consists of 10 sub-tests that enable the assessment of five cognitive domains: Attention and Executive Function, Language, Memory, Number processing, and Praxis. Non-verbal stimuli are used when possible in order to minimize the influence of aphasia on tasks that are not designed to assess language. Patients with aphasia are also given the option to respond in writing, or to point at multiple-choice answers, and are not penalised for this. In tasks that are not intended to assess neglect, stimuli are presented centrally along the vertical midline of the stimulus booklet. This reduces the influence of neglect on performance in tasks that are not aimed at assessing neglect. The ten sub-tests are described in detail in table 1.

[Table 1 about here]

[Figure 2 about here]

Participants

Ethical approval was given by the Local Ethics Committee at the Department of Psychology at the University of Copenhagen. The Department of Psychology at the University of Copenhagen and the Neurological department at Aalborg University Hospital participated in recruitment and data collection. A wide range of recruitment strategies were applied to ensure a broad range of education levels and participant ages. Recruitment was carried out by advertising, by staff announcements, and by contacting hospital and university volunteers. Exclusion criteria included previous or ongoing neurological disorder, visual field deficit revealed during assessment, and not having Danish as first language. Written informed consent was obtained from the participants prior to the study. A gift card worth 150 Danish Kroner was given to each participant as compensation. 93 participants enrolled for the study between September 2017 and April 2018. One participant was excluded because of possible cognitive decline (clinical signs of cognitive decline as well as a z score of -5.5 on the MoCA when adjusted for age, education and sex (Borland et al., 2017)) and one participant was excluded because the assessor was informed, post-assessment, that he/she had epilepsy (despite stating prior to testing that he/she had no neurological disorders). The final dataset included 91 participants between 36 and 87 years of age, who had 4 to 23 years of education (see table 2).

[Table 2 about here]

Procedure

Translation Process

The translation from English to Danish was carried out following the translation licence agreements with Oxford University Innovations, and specifically following the best practice guidelines provided in "Translation and Linguistic Validation Process" provided by Associate Professor Nele Demeyere, one of the developers of OCS. First, the British version was analysed to pinpoint possible items needing cultural adaptation/reconciliation. The sentence reading task was the only task that required cultural adaptation. A Danish sentence was developed that fulfilled all the necessary requirements in agreement with Associate Professor Nele Demeyere. The test was translated independently by two Danish neuropsychologists from English to Danish. Together with the project manager, the Danish neuropsychologists then agreed on a merged Danish version. This version was then translated back to English by a third neuropsychologist (Danish speaking with English as first language). The back-translation was reviewed by the project manager together with the original OCS developers, and minor adjustments were made after agreement with the UK developers. The test was piloted on five Danish stroke patients, which lead to the reading sentence being adjusted. The Danish version is available for use through Oxford University Innovations, who hold the copyright. The licences are free for use in publicly funded clinical practice and research. Links to the licence request pages can be found on www.ocs-test.org.

Results

Oxford Cognitive Screen

OCS data was collected from 91 participants, however, due to assessor omissions, only 89 participants performed the praxis sub-test. Mean scores for the whole sample (n=91) as well as for the different age and education groups are presented in table 3. As age and low education have previously been shown to be associated with lower scores on subtests of OCS (Mancuso et al., 2016), the influence of age and education on OCS scores in our sample was assessed using Pearson's correlation (one-tailed tests). Age correlated significantly with the following scores: Reading scores (Acc.) (r (89) = -.210, $p < .05$), Broken Hearts scores (RT) (r (89) = .504, $p < .01$), Praxis scores (Acc.) (r (87) = -.,226 $p < .05$), Recognition scores (Acc.) (r (89) = -.191, $p < .05$), as well as Triangle scores (Acc.) (r (89) = -.192, $p < .05$) and Alternating scores (Acc.) (r (89) = .316, $p < .01$) of the executive test. Correlations followed the expected direction for these subtests, with exception of the alternating accuracy scores of the executive test, for which performance improved with age. Higher education was associated with better Circle scores (Acc.) (r (89) = .191, $p < .05$) and Alternating scores (Acc.) (r (89) = .187, $p < .05$), but was surprisingly associated with worse Reading scores (Acc.) (r (89) = -.184, $p < .05$).

[Table 3 about here]

For most subtests, raw scores had a very narrow range and did not follow normal distributions and scores. Cut-offs for impairment were therefore determined using direct percentile conversions (Excel 2010 simple percentile function). Cut-offs were set at the 5th percentile (and 95th percentile for broken hearts subtest and executive task) and are provided in table 4.

[Table 4 about here]

Montreal Cognitive Assessment

The MoCA results are based on 88 participants as data points were missing for three participants (assessment errors). The mean score was 26.22 (SD=2.44) and the 5th percentile (Excel 2010 simple percentile function) corresponded to 22.35. The minimum score was 19, the maximum was 30, and the median score was 26.5. Scores correlated significantly (Pearson's correlation, one-tailed) with age ($r(86) = -.214$, $p < .05$) and education ($r(86) = .218$, $p < .05$).

Discussion

Regarding the OCS Results

The current study, by providing reference material for the OCS, represents an important first step in making a stroke specific screening tool available for clinical use in Denmark. A validation study in stroke patients is still needed to determine the full clinical use of the OCS in a Danish context, and to evaluate whether the OCS is indeed more sensitive to cognitive deficits following stroke than the MoCA.

Performance means of the Danish group were compared to those provided in the Italian (Mancuso et al., 2016) and the British (Demeyere et al., 2015) validation studies that are based on larger samples (see table 5). The means from the Danish sample were highly similar to those from the larger studies. Cut-offs were also, with some exceptions, found to be similar across studies (see table 6). When comparing Danish cut-offs to those provided in the Italian study (with the largest sample), small differences were observed for the Naming and the Praxis sub-tests, and a more substantial difference was observed for the Hearts cancellation test (accuracy as well as spatial and object asymmetry measures). As the sample used in the Italian study (N=489) is much larger than the sample in the current study (N=91), and as we do not expect cultural differences between Italy and Denmark to affect performances on this task, we recommend taking the Italian cut-offs into consideration when evaluating scores on the Hearts cancellation test. Indeed, for this sub-test, there may be a risk of under-diagnosing deficits when using the Danish cut-off for accuracy and a risk of over-diagnosing deficits when using the cut-offs (left and right) for spatial neglect.

[Table 5 about here]

[Table 6 about here]

In the large Italian study, scores were also shown to correlate with age and years of education on most of the subtests (Mancuso et al., 2016). However, despite these variables correlating with scores on many tests, there were only three measures for which the cut-offs had to be adjusted according to age and education in the Italian study: the naming measure (cut-off of <3 or <4), the Broken Hearts – correct measure (cut-off varied between <44 and <48) and the Recognition measure (cut-off of <3 or <4) (Mancuso et al., 2016). As described in the results section, scores also correlated significantly with age and/or education on some subtasks in the Danish sample. However, due to the modest size of the sample assessed and the uncertainties that this entails, separate cut-offs were not calculated for the different age and education groups in this study. Logistic regressions were however performed to investigate whether age and education predicted if participants scored below cut-offs or not for each OCS subtest. For most subtests, age and education did not predict whether participants performed below cut-off or not (p>.05). High age was only a significant predictor of performing below cut-off for the reading subtest (Acc.) (odds ratio=0.774; 95% CI= 0.6 – 0.998; p<.05) and low education was only a significant predictor of performing below cut-off on the circles (Acc.) part of the executive test (odds ratio= 1.453; 95% CI= 1.019-2.072; p<.05). Accordingly, while the use of a single cut-off does not seem to be a problem for most subtests, extra caution must be taken when interpreting the reading scores of elderly participants. Indeed, a score just below cut-off may simply be an expression of old age. For individuals with low education, extra caution must be taken when interpreting scores on the circles test. On this test, a score below cut-off may simply be an expression of low education.

Regarding the MoCA Results

There is currently no normative material available for the Danish version of the MoCA. Many health care professionals in Denmark therefore use the cut-off of 25/26 (1 point added to score if education ≤11) provided in the original Canadian validation study (Nasreddine et al., 2005). A recent international review found that when using a cut-off of 25/26, the MoCA has a poor specificity (over 40% of healthy controls scoring below 26 are false positives)(Davis et al., 2015). The results of the current study point in a similar direction. Indeed, by applying the original Canadian cut-off to the data, 31 of the 88 healthy participants (35.2%) would have been considered to have pathological performance, suggesting that the 25/26 cut-off currently used is likely to be unsuitable in a Danish context. The results of the current study suggest instead that a cut-off of 22/23 (corresponding to the 5th percentile in our sample) may be more appropriate.

Recent studies presenting normative data for translations of the MoCA have reported that scores are strongly associated with age, years of education, and gender, and that cut-off should be adjusted according to these variables. A recent Swedish normative study of a large population-Based cohort (N=860) (Borland et al., 2017), reported that cut-offs (placed at -1.5 SD) varied between ≤21 and ≤25, depending on participants' age, education, and gender. In a Spanish study (N=563), 5th percentile cut-offs varied between ≤18 and ≤25 (Pereiro et al., 2017). The differences between cut-offs provided in international studies illustrate the importance of using local norms for the MoCA.

Due to the modest sample size of the current study, we were unable to provide age and education-based norms for the Danish MoCA. Instead, a single 5th percentile cut-off is provided for the MoCA based on the whole sample. This consists a major limitation concerning the use of the present material in a clinical context. And while a logistic regression showed that age and education did not predict whether participants in the current study scored below the 22/23 cut-off ($p>.05$), results from larger international studies provide strong evidence that cut-offs should be adjusted according to these background variables. Thus, although the MoCA cut-off provided in this study (22/23) is likely to be more appropriate in a Danish context than the cut-off currently used in Denmark (25/26), a larger study is needed to provide strong age and education-based cut-offs for clinical use. Based on findings from larger international studies, one must acknowledge that by using the cut-off provided here, there is a risk of over-diagnosing cognitive deficits in participants who are elderly or have a low education level, and of under-diagnosing cognitive deficits in participants who are younger or have a high education level.

Regarding the use of screening tests

Many health care professionals use short dementia screening tools to screen for cognitive deficits in stroke. In Denmark, the MoCA is commonly used. Dementia screening tools suffer from various limitations when used in a stroke population: they put high demands on verbal abilities, do not enable evaluation of individual cognitive domains, and do not assess some of the cognitive symptoms which are common in stroke, such as neglect, apraxia and visual field deficits. The OCS—specifically designed for stroke patients—overcomes many of the limitations of dementia screening tools described above. It takes 15 minutes to administer, can be used at the bedside, enables assessment of individual cognitive domains, and reduces contamination of language deficits and neglect to tasks evaluating other cognitive domains.

Mean scores of the Danish sample on the OCS were similar to those provided by larger British (Demeyere et al., 2015) and Italian studies (Mancuso et al., 2016). The 5th percentile cut-offs were also similar to those provided in the large Italian study, increasing our confidence that despite the modest size of the sample in the current study, the Danish data presented here can be used in a clinical context. These findings must however be interpreted cautiously as the study suffers from various limitations. The first limitation of the current study is that only healthy participants were assessed. Although validation studies for the original version of the test (Demeyere et al., 2015) and for a Cantonese version (Kong et al., 2016) have proven content validity for the OCS, a validation study comparing performances on the OCS to commonly used neuropsychological tests in a Danish stroke sample would provide additional information on the clinical value of the Danish version of the test. The second limitation of the study is the lack of age and education-based norms. As scores on some subtests correlated with age and/or years of education, ideally, separate cut-offs should have been calculated for the different age and education groups. As the modest sample size would have yielded too much uncertainty in the results, such analyses were not carried out. It is important to discuss the risk that cut-offs on some tests might be too strict for participants in the older range and/or with lower education. Logistic regressions showed that age alone predicted whether participants scored below cut-off on a single test and the same was true regarding years of education. Also, despite scores correlating with age and education on many subtasks, results from the large Italian study suggest cut-offs would only need adjusting according to age and education for a few selected tests. Hence the risk can be considered to be limited. A larger Danish normative study is however needed to evaluate the extent to which age and education influence the appropriate cut-offs.

The current study did not involve assessment of a Danish stroke sample, thereby limiting the conclusions that can be made regarding which test should be preferred in a Danish stroke context. However, results from international studies provide evidence that the OCS is more sensitive to cognitive deficits following stroke than the MoCA and the MMSE (Demeyere et al., 2016; Mancuso et al., 2018). A British study compared the OCSs and the MoCAs abilities to detect cognitive impairments in acute stroke (N=200) (Demeyere et al., 2016). The OCS was shown to be more inclusive for patients with aphasia and neglect, less dominated by left hemisphere impairments, and generally more sensitive than the MoCA (87% vs 78%

sensitivity). A recent Italian study compared instead the OCS to the MMSE (n=325). While approximately a third of patients performed under the cut-off (<22) on the MMSE, 91.6% were impaired on at least one OCS domain, indicating higher sensitivity of the OCS. One hundred percent of participants who were impaired on MMSE showed abnormal performance on the OCS (Mancuso et al., 2018). It thus seems likely that the OCS-Dansk will provide a useful alternative to dementia tools currently used, when screening for cognitive deficits following stroke in Denmark.

On a final note, it is worth stressing that the OCS is a screening tool and is not therefore not designed to enable the identification of more discrete cognitive deficits. Subtle cognitive deficits cannot be fully ruled out on the basis of a performance that is within the normal range on the OCS. Neuropsychological assessment is still necessary for identifying discrete deficits and for providing more detailed descriptions of cognitive impairments.

Ethical approval: Ethical approval was waived by the Regional Ethics Committee (VEK) of Greater Copenhagen because the project was not considered to fall under the regulations of a health research project (Protocol number: H-17012594). The research protocol was approved by the Institutional Ethical Review Board of the Department of Psychology, University of Copenhagen (Approval number: IP-IERB / 26082017).

Contributors: R.J. Robotham was project manager for the research project. The study was designed in collaboration with N. Demeyere. Data collection was shared between R. Robotham and J. Riis. R. Robotham carried out data analysis and wrote the first draft of the paper. The manuscript was finished in close collaboration between the three authors.

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Table 1: Description of OCS sub-tests.

Task name	Domain	Description
Picture naming	Language (expressive)	Participants are asked to name four pictures, one at a time (1 point/correct response).
Semantics	Language (receptive)	Participants are presented with four pictures simultaneously on one page and asked to point, one at a time, to pictures belonging to different categories (1 point/correct response).
Sentence reading	Language (expressive)	Participants are asked to read a 15-word sentence presented in four rows centrally on a page. The sentence includes four irregular words and four “high-neighbourhood” words (words for which the start or end is shared with many other words), enabling screening for both surface dyslexia and neglect dyslexia (1 point /word that is read correctly).
Orientation	Memory (orientation)	Participants are asked open-ended questions about what city they are in and what time of day, month and year it is. If a participant is unable to respond due to language problems, multiple choice options are presented (1 point/correct response after use of multiple choice).
Recall and recognition	Memory (episodic)	The verbal episodic memory sub-test first involves the participants recalling the sentence from the reading sub-test. If a participant is unable to recall the sentence, a multiple choice task is presented to test if participants can recognise four target words. The recollection score represents the number of items correctly recalled before multiple choice (max four). The recognition score represents the recollection score plus points for additional items recognised with multiple choice (max 4). In the third part, participants are asked four questions about tasks completed earlier on (1 point/correct response).
Number writing	Number processing	Participants are asked to write down multi-digit numbers to dictation (1 point/correct response).
Calculation	Number processing	Participants are required to solve four mental arithmetic questions. If a participant is unable to respond due to language problems, multiple choice options are presented in writing (1 point/correct response).
Broken hearts test	Attention (visual attention)	Participants are presented with complete and incomplete hearts on a horizontal A4 page and are asked to cross out all the complete hearts. The incomplete hearts have a gap in the right or left side (see figure 2). A total correct score is provided with amount of full hearts correctly crossed out. A space asymmetry score is provided by subtracting the number of full hearts omitted on the left side of the page from the number of full hearts omitted on the left side of the page (positive score indicates left spatial neglect; negative score indicates right spatial neglect). An object asymmetry score is also calculated by subtracting the number of hearts with right gap that have been erroneously crossed out from the number of hearts with left gap that have been erroneously crossed out (positive score indicates left object-based neglect, negative score indicates right object-based neglect).
Trails task	Attention (executive function)	This is a trail test involves two simple tasks and one complex. In the two simple tasks, participants are required to connect circles amongst triangle distractors and then triangles amongst circle distractors. Items must be connected from the largest to the smallest. One point is given for each correct line. In the complex task, participants are asked to connect items by alternating between circles and triangles, whilst going from the largest to the smallest items. An executive score is calculated by subtracting the score on the alternating task from the scores on both simple tasks.

Imitating meaningless gestures	Praxis	Participants are required to copy two meaningless sequences of two hand gestures, and two hand positions made by the examiner (max. 3 points per gesture or hand position).
Visual field	Visual perception	A simple confrontation test is used to assess the four quadrants of the visual field. The assessor holds his/her hands up in the upper quadrants and moves the fingers of one and then the other hand. The participant is required to point to the hand that is moving. The same procedure is followed for the lower quadrants. A point is given for correct response in each quadrant.

Table 2: Number of participants in sample according to age and years of education

Education	Age			
Range (median)	36-65 (58)	65-75 (70)	75-89 (80)	Total: 36-89 (68)
4-12 (10)	*6*	*14*	*5*	25
12-16 (14.5)	*16*	*17*	*10*	43
16-22 (18)	*12*	*7*	*4*	23
Total: 4-22 (14)	34	38	19	91

Table 3: Mean scores according to age and years of education on OCS subtests

Task	Max	Overall	Age			Education		
			<65	65-75	>75	<12	12-16	>16
Naming	4	3.73	3.82	3.55	3.89	3.56	3.77	3.83
Semantics	3	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Orientation	4	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Visual field	4	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Reading [1, 2]	15	14.97	15.00	14.97	14.89	15.00	14.98	14.91
Writing	3	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Calculation	4	3.90	3.85	3.95	3.89	3.92	3.91	3.87
Broken hearts								
(Correctly crossed out)	50	47.02	46.82	47.08	47.26	46.28	47.26	47.39
Broken hearts (RT) [1]	180	103.56	88.78	103.37	130.39	105.32	103.24	102.24
Spatial asymmetry	0	0.08	0.00	0.08	0.05	0.00	0.05	0.09
Object asymmetry	0	0.04	-0.12	0.37	-0.16	0.24	0.07	-0.09
Praxis [1]	12	10.75	11.21	10.53	10.37	10.28	11.05	10.74
Recollection	4	2.65	2.65	2.71	2.53	2.52	2.79	2.52
Recognition [1]	4	3.87	3.97	3.82	3.79	3.84	3.84	3.96
Episodic memory	4	3.95	3.94	3.97	3.89	3.92	3.95	3.96
Circles (Acc.) [2]	6	5.95	6.00	5.95	5.84	5.88	5.95	6.00
Triangles (Acc.) [1]	6	5.91	5.91	5.97	5.79	5.84	5.93	5.96
Alternating (Acc.) [1, 2]	13	12.51	12.62	12.42	12.47	12.00	12.63	12.83
Executive Score	-1	-0.65	-0.71	-0.50	-0.84	-0.28	-0.74	-0.87

[1]Scores correlated significantly with age (Pearsons, one-tailed).
[2] Scores correlated significantly with years of education (Pearsons, one-tailed).

Table 4: Cut-offs for impairment on OCS based on the whole sample (5th percentile and 95th percentile)

	N	Min	Max	Median	Mean	SD	5th Centile	95th
Naming	91	1	4	4	3.73	0.52	3	
Semantics	91	3	3	3	3.00	0.00	3	
Orientation	91	4	4	4	4.00	0.00	4	
Visual field	91	4	4	4	4.00	0.00	4	
Reading	91	14	15	15	14.97	0.18	15	
Writing	91	3	3	3	3.00	0.00	3	
Calculation	91	3	4	4	3.90	0.30	3	
Broken hearts								
(Correctly crossed out)	91	29	50	48	47.02	3.84	39.5	
Broken hearts (RT)	91	35	180	101	103.56	29.83	63	161
Spatial asymmetry	91	-3	3	0	0.08	1.33	-2	2
Object asymmetry	91	-2	1	0	0.04	0.39	0	1
Praxis	89	7	12	11	10.75	1.42	8	
Recollection	91	0	4	3	2.65	1.07	1	
Recognition	91	2	4	4	3.87	0.40	3	
Episodic memory	91	3	4	4	3.95	0.23	3.5	
Circles (Acc.)	91	4	6	6	5.95	0.27	6	
Triangles (Acc.)	91	5	6	6	5.91	0.28	5	
Alternating (Acc.)	91	2	13	13	12.51	1.46	11	
Executive score	91	-3	9	-1	-0.65	1.42		1

Table 5: Mean scores compared across studies (Demeyere et al., 2015; Mancuso et al., 2016)

	Danish (N=89-91)	Italian (N=489)	British (N=140)
Naming	3.73	3.6	3.82
Semantics	3	3	3
Orientation	4	4	4
Visual field	4	4	4
Reading	14.97	14.8	14.85
Writing	3	3	2.93
Calculation	3.9	3.8	3.9
Broken hearts (Correctly crossed out)	47.02	47.1	47.31
Spatial asymmetry	0.08	-0.1	-0.11
Object asymmetry	0.04	0	0.01
Praxis	10.75	11.4	10.84
Recollection	2.65	-	2.52
Recognition	3.87	3.4	3.72
Episodic memory	3.95	3.9	3.83
Alternating (Acc.)	12.51	11.9	10.4
Executive Score	-0.65	-0.4	1.36

Participants in the British sample had a mean age of 65 (range: 36 to 88) and their mean length of education was 13,9 (Demeyere et al., 2015). The age of the participants in the Italian study ranged from 18 to 89 (Mancuso et al., 2016).

Table 6: Cut-offs compared across studies: 5th percentile (95th percentile)(Demeyere et al., 2015; Mancuso et al., 2016)

	Danish (n=89-91)	Italian (n=489)	British (n=140)
Naming	3	2.9 to 3.7*	3
Semantics	3	3	3
Orientation	4	3.9 to 4	4
Visual field	4	4	4
Reading	15	14.1 to 15	14*
Writing	3	2.8 to 3	3
Calculation	3	3.3 to 3.8	3
Broken hearts (Correctly crossed out)	39.5	43.4 to 47.4*	42*
Spatial asymmetry	-2 (2)	-3* (3)*	-2 (3)*
Object asymmetry	0 (1)	-2* (2)*	0 (0)*
Praxis	8	9*	8
Recollection	1	-	0*
Recognition	3	2.4 to 3.4	3
Episodic memory	3.5	3.4 to 3.8	3
Alternating (Acc.)	11	10.5 to 11	7
Executive score	(1)	(3)	(4)

*Cut-offs from international studies that differ from the Danish cut-offs.
In the Italian study, cut-offs were adjusted according to age and/or education for the sub-tests in which these variables influenced scores. For these sub-tests ranges of cut-offs are provided.

Figure captions:

Figure 1: Visual snapshot

Figure 2: Broken Hearts Test