Common Dementia Screening Procedures: DSM-5 Fulfilment and Mapping to Cognitive Domains

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Abstract

Background

Dementia is one of the pressing concerns in twenty-first century healthcare with close to 50 million sufferers worldwide. Its leading condition is Alzheimer's disease (AD), which is typically diagnosed by a specialised physician or clinician based on a set of criteria including factors such as: cognitive decline reported by a patient or their family members, a patient or their family's medical history, and the results of various cognitive screening procedures that are designed to measure the patient's cognitive abilities in different areas.

Objectives

Since there is an ever-growing variety of these medical procedures available, it can be hard to assess where each procedure fits in the process of screening AD, and more notably, how the contents of these procedures, i.e. tests and activities, map to cognitive domains assessed during the screening and diagnostic process.

Methods

Therefore, this research reviews and critically analyses a selection of the common dementia cognitive screening procedures such as the Alzheimer 's Disease Assessment Scale - Cognitive Subscale (ADAS-Cog), Clinical Dementia Rating Scale Sum of Boxes (CDR-SB), Everyday Cognition (ECog), and others. More importantly, we map screening procedures components including cognitive tests, questions and activities to the cognitive domains outlined in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5).

Findings

We found that no screening procedure covers the complete cognitive domains specified by DSM-5, and only CDR-SB covers the social cognition domain. Thus, CDR-SB would need to be combined with a medical procedure which includes complex attention and language such as ECog, ADAS-Cog, MMSE or MoCA to cover all cognitive domains specified by DSM-5.Mental Disorders Fifth Edition (DSM-5).

Keywords: Alzheimer's Disease; Cognitive tests; Cognitive science; Dementia; Neurology; Psychological Features

1. Introduction

Dementia describes a wide range of conditions that negatively affect brain function and cognitive ability. Approximately 50 million people worldwide suffer from dementia in one form or another (World Health Organization, 2019) but the most common type of dementia is Alzheimer's disease (AD), which accounts for 60% to 80% of cases (Alzheimer's Association. n.d.). Symptoms for AD include a progressive worsening of memory and learning ability as well as a decline in other cognitive areas. Despite being extensively studied there is still no known cure for AD, but when caught early, there are medications that can mitigate some of the symptoms and help people with AD maintain their independence for a while (Mayo Clinic, 2018).

When AD is diagnosed, typically by a clinician, usually a diagnosis of possible AD or probable AD will be made, since AD cannot be considered definite until an autopsy or biopsy on the brain is performed (United States National Institute on Aging, 2017). Studies have also been done to determine if biomarkers, such as measurements from magnetic resonance imaging (MRI) and positron emission tomography (PET) scans, and cerebrospinal fluid (CFS) readings taken from a lumbar puncture, can be used to improve AD diagnosis (Engelborghs et al., 2008; Mueller et al., 2005), but in a clinical setting these biomarkers are not often used. Instead, the two most common AD diagnostic bodies: the

Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (The American Psychiatric Association, 2013) and the Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA; McKhann et al., 1984), describe the process of diagnosing a patient with possible or probable AD.

Prior to a formal diagnosis of AD being made, there are a variety of cognitive screening procedures that aim to measure a patient's cognitive ability in different areas. While these procedures have been used successfully to demonstrate the presence of dementia, there is no clear consensus as to where these procedures fit into the process of a robust dementia screening methodology (Sachdev et al., 2014; Baldwin, & Farias, 2009). Therefore, this paper critically analyses an array of commonly used cognitive screening procedures to determine how they can be used specifically to correspond with the DSM-5 criteria for AD diagnosis. We seek to identify the medical procedures that cover wider ranges of diagnostic criteria based on the DSM-5 neurological areas related to dementia. This involves creating a mapping from tasks or sub-sections of cognitive screening procedures to their corresponding neurological areas. This can be a difficult task since neurological domains are not strongly defined, are hard to quantify, and procedure tasks or subsections can often overlap in measuring aspects of multiple neurological domains.

Additionally, we record the performance of these cognitive screening procedures via sensitivity and specificity metrics besides validity. It is our hope that this paper will provide a way to quickly, yet critically, compare a variety of cognitive screening procedures for the purpose of screening AD to fulfil DSM-5.

Furthermore, we have reviewed several papers which cover the process of screening for or diagnosing AD including Baldwin and Farias's (2009) research, which covers fulfilment of the DSM-3 and DSM-4 cognitive procedures criteria. However, we could not find an updated version covering the DSM-5 version of the criteria. More importantly, the authors did not include performance statistics for the selected procedures which we believe could be useful for a clinician deciding on which cognitive screening procedure to use. Finally, while there is some overlap in cognitive tests / activities (memory, learning, social cognition, motor skills, etc.) within these procedures, we decided on a distinct set of cognitive screening procedures to review in this paper.

This paper is structured as follows: Section 2 covers the process of neurocognitive disorder and AD diagnosis according to the DSM-5 criteria. Section 3 is a literature review focusing on how cognitive screening procedures fit into the process of screening dementia. Section 4 is a review of the seven common cognitive screening procedures we selected. Section 5 is a discussion about the performance and suitability of the cognitive procedures, and finally conclusions are given in Section 6.

2. Dementia diagnosis process and requirements

The American Psychiatric Association (2013) in DSM-5 describes the criteria for diagnosing possible and probable AD. First, some level of dementia or neurocognitive disorder must be established. Major neurocognitive disorder (major ND) requires that the patient experience a significant decline over time in at least one of the following six cognitive domains: complex attention, executive function, learning and memory, language, perceptual-motor, or social cognition. This can be reported either by the patient, an informant, or the clinician, and then corroborated by performing a cognitive test that is associated with the domain. Secondly, the cognitive deficits experienced by the patient must interfere with their independence during everyday activities. Alternatively, minor neurocognitive disorder (minor ND) requires a moderate decline in cognitive domains over time and that the patient's independence during everyday activities is not affected. Both major ND and minor ND also require that the cognitive defects are not only observed when the patient is delirious, and the cognitive defects are not better explained by another mental disorder.

Once major ND or minor ND has been demonstrated, the DSM-5 criteria can be used to determine if the observed disorder is being caused by AD. In addition to the above criteria, there must be a gradual progression of impairment in one or more of the six cognitive domains mentioned earlier.

For a patient with major ND, AD is probable if either there is evidence of AD from family history or genetic testing, or there is clear evidence of a decline in memory and learning as well as one other cognitive domain and the cognitive decline must have a steady but gradual progression (see Tables 1 and 2). If either condition is not met in a major ND patient then AD is possible.

For a patient with minor ND, AD is probable if there is evidence of AD from family history or genetic testing, otherwise AD is possible if there is clear evidence of a decline in memory and learning as well as one other cognitive domain and the cognitive decline must have a steady but gradual progression.

Typically, when AD diagnosis is needed for research purposes, a more rigorous diagnosis criteria is required. In the Alzheimer's Disease Neuroimaging Initiative (ADNI) study (ADNI, 2017), AD subjects have been diagnosed as having probable AD according to the Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria (McKhann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984). This involves a MMSE score between 20 and 26 and a CDR-SB of 0.5 or 1.0.

Table 1. Major ND and Minor ND description

Major ND	Significant cognitive decline in one or more cognitive domains	The cognitive deficits interfere with independence in everyday activities.	The cognitive deficits do not exclusively occur in the context of delirium	The cognitive deficits are not better explained by another mental disorder.
Minor ND	Modest cognitive decline in one or more cognitive domains	The cognitive deficits do not interfere with independence in everyday activities.	The cognitive deficits do not exclusively occur in the context of delirium	The cognitive deficits are not better explained by another mental disorder.

Table 2. AD diagnostic criteria based on DSM-5

			Major ND	**Minor ND**
Probable AD	Major or Mild Neurocognitive Disorders criteria are met.	Evidence of AD from family history or genetic testing Or: Clear evidence of decline in memory and learning and one other cognitive domain, Steady gradual decline in cognition, And no evidence of other neurodegenerative disease.	Evidence of AD from family history or genetic testing	
Possible AD	Major or Mild Neurocognitive Disorders criteria are met.	None of the above.	All three of the following: Clear evidence of decline in memory and learning and one other cognitive domain Steady gradual decline in cognition No evidence of other neurodegenerative disease	

3. Literature Review

Baldwin & Farias (2009), reviewed the coverage of DSM-3, DSM-4 and NINCDS-ADRDA criteria for AD

diagnosis for various cognitive procedures. This includes measuring impairment in the cognitive domains defined in the DSM-5, and assessing a subject's ability to carry out activities of daily living (ADL). The authors noted that while cognitive impairment was typically defined as having cognitive screening procedure scores more than 2 standard deviations outside of the mean for control groups, it was somewhat difficult to quantify problems with daily living. Instead, it was reported that this area of diagnosis is usually based on reports from an informant or the patient themselves, though there are some cognitive screening procedures, such as Ecog, that do attempt to provide a standard for measuring ADL by having fixed questions about a subject's everyday functioning. Finally, the authors looked at several procedures which measure other neuropsychiatric symptoms such as depression, anxiety or apathy that have been linked to AD, but these are not required for AD diagnosis.

Sachdev et al. (2014) reviewed the DSM-5 criteria for diagnosing various neurocognitive disorders including AD. The authors stressed the need for a common and objective method for classifying dementia and AD. While DSM-5 does partially address this by describing six principal cognitive domains that can be used to evaluate dementia, the criteria do not prescribe any specific procedures for the measurement of these domains.

Alberdi, Aztiria, & Basarab (2016) provided a highly detailed review of different measures that can be used for AD detection and diagnosis including cognitive tests and biomarkers. Stressing the need to diagnose AD as early as possible, the authors advocated for a multimodal approach using a combination of different test results including MRI, which they found to have the highest accuracy (98.95%) when discriminating AD from a control group, and electroencephalogram (EEG) which had the highest accuracy (97.88) for discriminating mild cognitive impairment from control. The authors also noted that while cognitive screening procedures are cheaper and easier to carry out than most biomarker tests, the types of cognitive decline that are measured by cognitive procedures only occur when dementia is already established in the patient, at which point the damage is impossible to reverse.

Scinto & Daffner (2000), in their book about the early diagnosis of AD, also highlight the need to use biomarkers to try and detect the presence of AD before the symptoms of cognitive decline arrive. Nevertheless, the authors point out that currently the most accepted methods of AD diagnosis are the DSM or NINCDS-ADRDA criteria, although the extent to which these criteria were followed in a clinical setting was brought into question. In their section covering cognitive screening procedures the authors noted that this part of AD diagnosis could have a large amount of variation from clinic to clinic since there was no real consensus on which cognitive procedures to use. Another challenge brought up by the authors was the need for a recorded or reported history of the patient since AD diagnosis requires a progressive deterioration in cognitive ability over time. This means repeated cognitive procesures would be needed to demonstrate the changes in cognitive function.

Dubois, Padovani, Scheltens, Rossi, & Dell'Agnello (2016) reviewed the benefits and challenges of producing a timely diagnosis of AD. Where early AD diagnosis aims to detect the presence of AD before symptoms arise, this would require subjects with still apparently normal cognition to be screened. Instead timely diagnosis of AD aims to make a diagnosis as soon as the subject or their family members report a cognitive ability concern. The authors also reported on research papers which covered the cost analysis of timely AD diagnosis, concluding that while effective diagnosis could cost more upfront, this could be offset by reducing the time spent in specialised care if a patient receives medication at an early stage in AD.

4. Common Cognitive Screening Procedures for Dementia

4.1 Alzheimer 's Disease Assessment Scale - Cognitive Subscale (ADAS Cog)

ADAS-Cog (Rosen, Mohs, & Davis, 1984) is a procedure designed to measure the level of cognitive dysfunction in a patient. While its use for monitoring pre-dementia and mild cognitive impairment have been criticized (Kueper, Speechley, & Montero-Odasso, 2018) it is generally accepted as one of the commonly used procedures for assessing dementia. It is typically administered by a professional and consists of 11 structured and unstructured tasks: word recall, naming objects and fingers, commands, constructional praxis, ideational praxis, orientation, word recognition, language, comprehension of spoken language, word finding, and remembering test instructions. ADAS-Cog

usually takes 45 - 60 minutes to complete in a clinical setting and produces a score between 0 and 70, with 70 indicating the most severe cognitive dysfunction. In addition to the 11-question version, there exist some variations: ADAS-Cog 13 additionally contains a delayed word recall section and a maze or number cancellation section and is scored between 0 and 85 (Mohs et al, 1997). Monllau et al (2007) tested the ADAS-Cog's ability to diagnose AD on a sample of 451 subjects (of which there were 254 control subjects with normal cognition, 86 with mild cognitive impairment and 111 with AD). They found that the best cut off score for describing AD was >=12 which had a sensitivity of 89.19% and a specificity of 88.53%.

4.2 Clinical Dementia Rating Scale Sum of Boxes (CDR-SB)

After extensive researching, Hughes et al. (1982) had not found an appropriate scale for the purpose of separating the stages of dementia for a project initiated in 1979. The authors had to introduce a new rating scale, Clinical Dementia Rating Scale (CDR), to address the problem. The CDR consists of two sets of interrelated semi-structured interview guidelines/questionnaire, which incorporate assessment of the following six cognitive domains: memory, orientation, executive (judging and problem solving), community affairs, home and hobbies and personal care. An informant is interviewed ahead of the subject to form a baseline understanding of the subject's cognitive degradation level. The clinician validates the subject's answers by comparing to the informant information, then assigns a score of 0 (normal cognitive function), 0.5 (very mild cognitive impairment), 1 (mild cognitive impairment), 2 (moderate cognitive impairment) and 3 (severe cognitive impairment) for each category. The final sum of the scores (SB: Sum of Boxes) ranges from 0 (normal) to 18 (severe), where any subject scoring less than 4 will indicate very mild dementia or light cognitive degradation. A mildly demented subject will likely score between 4.5 and 9, when a moderately demented subject will score between 9.5 and 15.5, and anyone scoring over 16 is considered severely demented (Mennella & Heering, 2015). Within the study, sensitivity and specificity have not been disclosed, however, in another validation study conducted by O'Bryant et al. (2017), 80% in sensitivity and 69% in specificity have been reported.

4.4 Everyday Cognition (ECog)

Everyday Cognition (Farias et al., 2008) is a questionnaire which was created with the goal of increasing sensitivity especially towards the mild cognitive impairment group, over pre-existing cognitive screening procedures. Based on input from domain experts such as clinicians and neurologists, the ECog started off with 138 potential questions which was reduced to a final total of 39 questions with 4 possible responses to each question:

1 = better or no change compared to 10 years earlier,

2 = questionable/occasionally worse,

3 = consistently a little worse,

4 = consistently much worse.

There are two versions of ECog: an informant-based version (ECogSP) where the questions are answered on behalf of the patient by their caregiver, and a patient-based version (ECogPT) where the subject answers the questions.

Furthermore the questions can be divided into six categories: Memory, language, semantic knowledge, visual spatial, planning, organisation and divided attention. All questions also count towards a general category, which is a function of all other categories. Each category is then rated on a scale of 1 to 4, with 4 representing the most severe decline in everyday function. The authors reported that when targeting cut off points for a specificity of 80%, sensitivity was 93% in discriminating dementia from Cognitively Normal (CN), 75% in discriminating Mild cognitive Impairment (MCI) from dementia, and a 67% in discriminating MCI from CN.

4.4 Functional Activities Questionnaire (FAQ)

In order to access the living independence level of elderly in community setting, Pfeffer et al. (1982) considered Lawton and Brody's (1969) Instrumental Activities of Daily Living (IADL) Scale, which were initially developed for the assessment of independent living of injured patients, to be relevant. Based on the foundation of IADL, the authors developed the Functional Activities Questionnaire (FAQ) that contains 10 questions, which are the grouped daily tasks for independent living. Each question is rated on a scale of 0 to 3, where lower scores indicate better autonomy. Scores are then totalled for a scale between 0 and 30. The cut-off point is 9 for determining if one has impaired functions. Instead of a trained medical professional to administer the test in a clinical setting, an informant such as the spouse, a close friend or relative of the intended subject is able to administer the test in the comfort of their own home. Within the study, FAQ has reported 85% in sensitivity while IADL achieved only 57%, however, in regard to specificity, IADL has achieved 92% when FAQ reported 81%.

4.5 Mini Mental State Examination (MMSE)

Folstein et al. (1975) created the Mini Mental State Examination (MMSE) with a significantly shorter administration time of 5-10 minutes compared to other cognitive screening procedures. MMSE only consists of 11 questions to address the issue of shorter period of mental concentration in elderly patients, and is administered in a clinical setting. In comparison, other mental state tests usually assess the full mental state and take more than 30 minutes. The authors focused on assessing the cognitive functions of perception, visual, memory, language and fine motor skills. MMSE has a total score of 30 and anyone who scores less than 24 indicates some level of cognitive impairments. The authors have validated the screening method on a sample of 269, 63 healthy subjects and 206 patients who exhibited various types of abnormal mental symptoms, including dementia. Within the initial publication of MMSE, there is no information on its sensitivity and specificity. However, in 2000, a validation study with 151 subjects in Greece reported 90.8% sensitivity and 90.6% specificity with the cut off score 23/24 (Fountoulakis, Tsolaki, & Chantzi, 2000), as specified by Folstein et al. (1975).

4.6 Montreal Cognitive Assessment (MoCA)

MMSE is well-known for its insensitivity in separating MCI subject from normal subject (Ihl, Lutz, Dierks, Martin, & Maurer, 1992; Tombaugh & McIntyre, 1992; Wind, et al., 1997), which is why Nasreddine et al. (2005) created MoCA as a quick screening instrument for detecting MCI and Mild AD. If a subject score within normal ranges on the MMSE, but is still experiencing memory issues, further testing in MoCA can help determine whether the subject suffers from MCI or Mild AD. The authors designed 12 structured and unstructured questions which only take around 10 minutes to complete, including activities of drawing cube and trail making, to assess the subjects' attention, abstraction, executive, memory, orientation and visuospatial capabilities in a clinical setting. Within the study, MoCA was able to separate 90% of MCI subjects where MMSE only managed to separate 18% (Nasreddine, et al., 2005). The impairment cut off score was set to 26 where the maximum score is 30, the study reported a specificity level of 87%, the sensitivity for discriminating MCI and Mild AD was 90% and 100% respectively.

4.7 Rey's Auditory Verbal Learning Test (RAVLT)

RAVLT (Rey, 1941, & Schmid,1996) is a test where the subject is given a first set of 15 nouns which they are asked to recall. They are again given the nouns and asked to recall again, a total of 5 times. Next, they are given a second set of 15 different nouns but asked to again recall the first ones. The subjects are then given a 30 minute break and asked to recall the first set of nouns again, finally the subjects are asked to identify the original 15 nouns from a set of 50 nouns including the first and second sets. The RAVLT test produces a number of different summary scores but only two of which are used in the ADNI dataset (Moradi, Hallikainen, Hänninen, Tohka,, & Alzheimer's Disease Neuroimaging Initiative, 2017). *RAVLT immediate* is the total number nouns recalled in the first 5 repetitions, giving a score that ranges from 0 to 75. *RAVLT percent forgetting* is the proportion of

nouns remembered in the 5th trial that are forgotten after 30 minutes (the score of the 5th repetition, minus the score after the 30 minute break, divided by the score of the 5th repetition, and multiplied by 100). *RAVLT percent forgetting* can in theory range between -1400 (assuming at least 1 is recalled in the 5th trial since you can't divide by 0) and 100, with negative scores meaning the subject remembered more nouns after the break and 100 meaning the subject forgot all nouns after the break. *RAVLT immediate* is typically associated with learning memory and *RAVLT percent forgetting* with delayed memory.

5. Discussion

In the cognitive screening procedures selected, as seen in Tables 3, it is obvious that the intentions of each procedure are different, since the clinical researcher's study focus was varied. For instance, the MMSE has been used as a dementia screening tool since its inception in 1975, and while MoCA is focused more on differentiating MCI patients from SMC, the MMSE is known for its insensitivity (Ihl, Lutz, Dierks, Martin, & Maurer, 1992; Tombaugh & McIntyre, 1992; Wind, et al., 1997 & Nasreddine et al., 2005). CDR-SB and Ecog are considered as dementia diagnosis procedures, which segregate the subjects into different stages of dementia progression, such as mild MCI, MCI, moderate dementia and severe dementia.

RAVLT is unique in that is not designed primarily for the screening of dementia, however it is an effective tool for measuring the cognitive domain most associated with dementia: Memory. As such it's use has been explored as a possible component of robust dementia screening toolkits (Ghafar, Miptah, & O'Caoimh, 2019; Dawidowicz, Ash, EKorczyn, Andelman, Levy, & Elkana, 2021).

5.1 DSM-5 Fulfilment

The DSM 5 criteria do not require any specific cognitive procedures be used in the process of AD screening and diagnosis, however cognitive tests within these procedures can be used to measure decline in one or more of the six cognitive domains: complex attention, executive function, learning and memory, language, perceptual-motor, or social cognition. Decline in at least one of these domains is required by DSM 5 for major and minor ND and decline in learning and memory as well as at least one other domain is required for AD. Furthermore, the severity of decline can determine whether the neurocognitive disorder is major or minor and if AD is probable or possible. Therefore, it is beneficial to use cognitive tests which are quantified and equitable, to measure decline in cognitive domains. Table 4 depicts which of the six cognitive domains is covered by each screening procedures and Table 5 depicts which sections / cognitive tests of each screening procedure relate to each cognitive domain.

We have used the definition of each cognitive domain according to the Johns Hopkins Psychiatry Guide (Peters, & Rabins, 2017). Complex attention includes sustained, divided, and selective attention, ability to concentrate and perform mental calculations. Executive function includes planning, decision making and ability to organise. Learning and memory includes immediate, recent, and long-term memory. Language includes remembering names of objects or people and using correct grammar. Perceptual motor includes visual perception and ability to navigate familiar environments and perform spatial tasks. Social cognition includes the recognition of emotions, theory of mind, and an awareness of social standards.

RAVLT was the only cognitive test we reviewed that only covers one cognitive domain, being learning and memory, however it can be useful to individually measure different aspects of the learning and memory domain such as immediate recall and delayed recall. All other considered cognitive screening procedures could be applied to more than one cognitive domain, however there was no cognitive screening procedures that covered all six domains. ECog had the largest coverage including all domains apart from social cognition. In fact, CDR-SB was the only procedure found that could be considered to cover social cognition as part of the 'community affairs' test. While this assesses behaviours likely to relate to social cognition, such as reactions in social situations and consideration of others, it does not directly assess the socio-emotional or mentalizing skills usually considered central to the social cognition domain. Nor does the CDR-SB cover complex attention or language. To

cover all cognitive domains in DSM-5, you would need to combine CDR-SB with another cognitive screening procedures such as ECog or alternatively ADAS-Cog, MMSE, or MoCA which each cover all cognitive domains apart from social cognition and executive function.

It is worth highlighting too, that while some of the cognitive screening procedures include cognitive tasks to measure functioning in DSM domains directly, others rely on descriptions of routine behaviours that we assume will be impacted by poor cognitive functioning. For example, the ADAS-Cog measures perceptual and motor skills directly by asking patients to copy geometric shapes. In contrast, the CDR-SB 'home and hobbies' test asks about patient abilities to conduct chores and routine tasks and to use appliances. Functioning impairment in these tasks could indicate difficulties with perceptual and motor skills, but may also reflect issues in executive functioning.

The cognitive domains required for diagnosing possible or probable AD according to the NINCDS-ADRDA criteria differ slightly: replacing social cognition with orientation and adding constructive abilities and problem solving. Therefore, a different set of cognitive screening procedures is required. All cognitive screening procedures mentioned here aside from RAVLT also cover orientation. ADAS-Cog covers constructive abilities and CDR-SB can evaluate a subject's problem-solving ability.

5.2 Performance

Table 3 shows the cognitive screening procedures performance in terms of sensitivity and specificity based on critical reviews. Sensitivity refers to the ability to correctly classify subjects with AD, specificity refers to the ability to correctly classify subjects without AD. In general sensitivity and specificity are inversely proportional to one another as you change the cognitive procedure's cut off point. Therefore, cut off points are chosen carefully to maximise both measures as needed.

The results below show that MoCA was the highest performing procedure, with a sensitivity of 90% towards MCI subjects and a sensitivity of near 100% towards AD subjects as well as a specificity of 87% for both MCI and AD. For some of the original studies, there were no disclosed sensitivity, specificity or cut off scores. In these cases, we have found validation studies or comparison studies which provide such information (O'Bryant, et al., 2010; Hsu, et al., 2017& Li, Guo, Qin, & Hao, 2017). For RAVLT, we were unable to locate any studies specifically linked to dementia diagnosis with an overall sensitivity and specificity. The likely reason is that RAVLT was not comprehensive enough to use for dementia screening or diagnosis due to its narrow scope. For the rest, CDR-SB seems to perform worse with only 80% sensitivity and 69% sensitivity when the others were all above 85% sensitivity and 80% specificity. Ecog performed better than CDR-SB in discriminating dementia from control, with a 93% sensitivity and 80% specificity.

5.3 Accessibility and Administration

The majority of these cognitive screening procedures require clinicians or trained clinical professionals to administer, FAQ is the only cognitive test which can be performed in a community setting.

Since most of these cognitive screening procedures were constructed to have less than 15 questions, except ECog, and RAVLT, the administration duration is reasonably short. The 11 tasks of ADAS Cog are usually administered over a period of 45 to 60 minutes, CDR-SB usually takes around 30 minutes. MMSE and MoCA are the quickest of the cognitive screening procedures in this paper with an administration time of only 5 to 10 minutes and 10 minutes respectively.

Since demonstrating cognitive decline in memory and learning and one other cognitive domain is the requirement for possible and probable AD according to the DSM-5 criteria, it could be beneficial to begin testing with a quick cognitive screening procedure such as MMSE or MoCA. This can be used to demonstrate impairment in memory and learning and three of the other cognitive domains, and could be followed by use of CDR-SB if there is found to be an impairment of memory and learning but no impairment in complex attention, language and perceptual motor skill.

6. Conclusions

The process of diagnosing dementia according to the DSM-5 criteria requires progressive impairment

to be demonstrated in one of six cognitive domains: complex attention, executive function, learning and memory, language, perceptual-motor, and social cognition. Prior to diagnosis, subjects may be assessed using a variety of cognitive screening procedures, however DSM-5 does not prescribe any specific test to be used, so when screening AD according to DSM-5, the clinician must use a selection of cognitive screening procedures that cover the six domains specified in DSM-5.

After looking at a selection of commonly used cognitive screening procedures, we have mapped each procedure's sub-sections or tasks onto the neurological domains specified in DSM-5 which the subsection or task aims to measure. We found no one procedure covered all cognitive domains specified by DSM-5, and only CDR-SB covered the social cognition domain. Therefore CDR-SB would need to be combined with a medical procedure which includes complex attention and language such as ECog, ADAS-Cog, MMSE or MoCA to cover all cognitive domains specified by DSM-5.

While this paper does not definitively settle the issue of selecting which cognitive screening procedure to use when diagnosing or screening for dementia according to DSM-5 criteria, it does provide a foundation on which clinicians can compare some of the commonly used cognitive screening procedures and see how they fit into the DSM-5 criteria. Since no single medical procedure reviewed here covers all six cognitive domains involved in DSM-5 diagnosis criteria besides there being a certain unstructured activity that can cover multiple cognitive domains (overlapping of cognitive domains within the tests / activities of the cognitive screening procedures), a selection of at least two procedures is required. Therefore, deciding which cognitive screening procedures to use could come down to factors including how many cognitive domains it covers besides sensitivity, specificity, or the time it takes to administer.

In the future, this paper could be expanded by considering various other cognitive screening procedures, as well as looking for additional critical evaluation studies on the selected procedures. In addition, there are other methods of evaluating the cognitive screening procedures that could be investigated, such as the reliability of the medical procedure to provide the same result when administered by different clinics. Moreover, it will be advantageous to mathematically model the scores and cut offs provided in these cognitive screening procedures so if a clinician has a value of one screening procedure, the system will be able to offer him the equivalent values in other screening procedures despite these procedures' different ranges and scores. More importantly, with the growth of technology such as artificial intelligence (AI) in the health care sector, it would also be interesting to look at how machine learning methods can be used to combine the results of various cognitive screening procedures to provide a more accurate and efficient AD diagnosis. AI and machine learning can be embedded in Computer Aided Diagnosis systems for AD offering powerful decision-making tools for medical professionals.

Table 3 Cognitive Diagnostic Procedures Details										
Procedure	**Name**	**Type**	**No. of Question**	**Cut Off Score**	**Min Score**	**Max Score**	**Sensitivity**	**Specificity**	**Administration Settings**	**Activities**
ADAS	Alzheimer's Disease Assessment Scale	Dementia Screening	11	12	0	70	89.2%	88.5%	Clinical	Drawing
CDR-SB	Clinical Dementia Rating Scale Sum of Boxes	Dementia Severity	6	2*	0	18	80%*	69%*	Clinical	N/A
ECog	Everyday Cognition	Dementia Severity	39	1.23* 1.92*	1	4	93% Dementia from Normal; 75% MCI from Dementia; 67% MCI from Nomal	80%	Clinical	N/A
FAQ	Functional Activities Questionnaire	Dementia Screening	10	9	0	30	85%	81%	Community	N/A
MMSE	Mini-Mental State Exam	Dementia Screening	11	23/24*	0	30	90.8%*	90.62%*	Clinical	Drawing
MoCA	Montreal Cognitive Assessment	MCI Dectetion	12	26	0	30	90% MCI;100% AD	87%	Clinical	Drawing &Trail making
RAVLT	Rey Auditory Verbal Learning Test	Memory	8 Trials	N/A	0	75	N/A	N/A	Clinical	N/A

Procedure	Table 4 Cognitive Domain Coverage						
	Social Cognition	**Complex Attention**	**Learning and Memory**	**Executive Function**	**Language**	**Perceptual Motor Skill**	**Original Ref**
ADAS	No	Yes	Yes	No	Yes	Yes	Rosen et al., 1984
CDR-SB	Yes	No	Yes	Yes	No	Yes	Hughes et al., 1982
ECog	No	Yes	Yes	Yes	Yes	Yes	Farias et al., 2008
FAQ	No	Yes	Yes	Yes	No	Yes	Pfeffer et al., 1982
MMSE	No	Yes	Yes	No	Yes	Yes	Folstein et al,1975
MoCA	No	Yes	Yes	No	Yes	Yes	Nasreddine et al. (2005)
RAVLT	No	No	Yes	No	No	No	Schmidt. (1996)

Procedure	Table 5 Mapping of Procedure Sections to Cognitive Domains						
	Social Cognition	**Complex Attention**	**Learning and Memory**	**Executive Function**	**Language**	**Perceptual Motor Skill**	**Original Ref**
ADAS-Cog	None	Ideational Praxis	Word recall, Orientation, Word recognition, Remembering test instructions	None	Commands, spoken language ability, naming objects/fingers, word finding difficulty, comprehension.	Constructional Praxis	Rosen et al., 1984
CDR-SB	Community affairs	None	Memory, Orientation	Judgment and problem solving	None	Home and Hobbies	Hughes et al., 1982
ECog	None	Divided Attention	Memory	Planning, Organisation	Language	Visuospatial	Farias et al., 2008
FAQ	None	Questions 1,2,4,7,8	Question 9	Questions 3,10	None	Questions 5,6	Pfeffer et al., 1982
MMSE	None	Attention and Calculation	Orientation, Registration, Recall	None	Language	Copying	Folstein et al,1975
MoCA	None	Attention.	Memory/delayed recall, Orientation	None	Naming, Language, Abstraction	Visuospatial/executive	Nasreddine et al.(2005)
RAVLT	None	None	Immediate, Percent forgetting	None	None	None	Schmidt. (1996)

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