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Development of a contextually relevant cognitive driving screen: CoDriS

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DEAR EDITOR

INTRODUCTION

Comprehensive driving evaluations by occupational therapists assess whether individuals have the necessary physical, cognitive, visual and sensory abilities to drive in traffic[1]. These evaluations typically commence with a clinical, office-based assessment to identify abilities and limitations, followed by an on-road assessment[2]. Focusing on cognition, clinicians assess various cognitive domains essential for both managing routine, automated aspects of driving and responding effectively to dynamic traffic conditions.

In clinical practice, general cognitive tests are used to assess domains relevant to driving, supported by researched cut scores for driving fitness. However, these tests were typically developed outside South Africa and are not normed on the local population. General cognitive tests are also not driving-specific and do not assess practical driving knowledge. This makes it challenging to interpret how scores relate to actual driving ability, both for clinicians and for those being assessed.Since these tests do not assess familiarity with traffic rules or the ability to navigate real traffic conditions, assessors have limited insight into the individual's driving knowledge before conducting the on-road assessment.

To strengthen the link between clinical assessment findings and actual driving performance, and to mitigate for safety during the on-road assessment, the first author (a clinical expert in the field) is in the process of developing a cognitive screening instrument that combines the assessment of relevant cognitive domains with driving-related knowledge required for independent driving, namely the Cognitive Driving Screen (CoDriS). The instrument development process is following the MEASURE approach, an acronym for seven pragmatic steps in instrument development and initial validation proposed by Kalkbrenner (see Figure 1, below)[3]. This scientific letter presents the methods and results related to the first four steps shown in Figure 1, below



Figure 1: The MEASURE approach to instrument development[3]

METHOD

1. Make the purpose and rational clear

In the first step of the MEASURE approach [3], the purpose of the proposed measure is made explicit, explaining why it is important to assess the chosen construct. This involves clearly defining the construct by asking, "What do we want to measure?" Constructs are often complex and multidimensional, encompassing several variables that must be considered. The COnsensus-based Standards for the selection of health status Measurement INstruments (COSMIN) group describes a construct as "a well-defined and precisely demarcated subject of measurement" [4,pg.169]. Additionally, a rationale is provided to highlight gaps in the current knowledge base and explain how addressing these gaps can advance both practice and research[3].

Cognitive domains

Driving requires multiple cognitive domains; thus, comprehensive driving evaluations typically combine existing cognitive tests with researched cut scores to determine fitness to drive. Commonly used instruments include the Montreal Cognitive Assessment (MoCA), Trail Making Tests A and B, Snellgrove Maze and Useful Field of View (UFOV)[5–7]. Composite batteries such as the Occupational Therapy Driver Off-Road Assessment Battery (OT-DORA) and Rookwood Driving Battery are also used[8,9]. None of these tests or their cut scores were developed for the South African context, limiting local applicability[10].

Existing cognitive tests are based on general concepts that assume baseline language, literacy, numeracy and cultural knowledge. Interpreting how these test items relate to driving requires further analysis and individuals with cognitive impairment often struggle to understand how abstract test results impact their driving ability. Additionally, in the absence of South African cut scores, assessors must carefully consider the relevance of test scores in light of the individual's educational and social background.

Driving knowledge

Most cognitive tests used do not assess an individual's driving knowledge, which is central to the learnt skill of driving. The Road Law and Road Craft Test (RLRCT) in the OT-DORA battery addresses this by evaluating knowledge of left-hand driving traffic rules[8,11]. The RLRCT utilises multiple-choice questions, written reasoning and sequencing tasks based on Australian and UK road rules[8,11]. While useful, some South African drivers struggle with the format and the subtle differences in international traffic rules, often due to language and educational factors rather than cognitive impairment.

Driving assessments typically focus on on-road driving performance. However, occupational therapists also consider broader occupational demands, such as trip planning and handling unforeseen events. Existing standardised cognitive tests largely target on-road performance; therefore, the first author identified a need to assess additional trip-related skills to better evaluate an individual's capacity to manage an entire journey.

Insight

Insight is a critical cognitive domain in driving assessments. Understanding one's limitations and their potential impact on driving helps ensure responsible behaviour. Self-assessment questions that ask individuals to rate their ability to handle various traffic situations can be compared to objective test results and on-road performance to understand how their perceived ability aligns with their actual ability.

Instruments used include the Brain Injury Driving Self-Awareness Measure (BIDSAM)[12], completed by the driver and assessor post on-road assessment; the Fitness-to-Drive Screening Measure[13] , completed by a proxy and self-report tools such as the Drivers 65 Plus Self Rating Form[14]. Given the importance of insight, the first author included self-assessment items where individuals rate their ability to manage trip planning and driving conditions that mirror scenarios tested in the CoDriS. This enables comparison between perceived and actual performance.

Instrument administration

Several paper-based cognitive tests require sufficient fine motor dexterity, which is not essential for driving; thus, individuals with fine motor impairments may score poorly despite adequate cognitive ability. Similarly, tests which require verbal responses disadvantage those with communication disorders such as aphasia, even if their driving-related cognition is intact, highlighting the need for alternative formats.

Some of the tests that were explored rely on assessor scoring and interpretation. Although administrator training is available, minor adaptations to test instructions and scoring in clinical practice introduce variability, which may affect standardisation.

The first author recognised the potential to develop an online assessment format that minimises fine motor and verbal communication barriers, with automated scoring to ensure standardised results.

2. Establish the empirical framework

The empirical framework clarifies how the instrument's items relate to the construct being measured[4]. The theoretical basis is made explicit and the authors outline how items were selected to best capture the construct[3].

In the first instance, clinical need and discussions with occupational therapists experienced in comprehensive driving evaluation informed the driving-related content. The theoretical framework of Michon's hierarchical model of cognition and driving behaviour[15], which divides cognitive control in driving into strategic (planning, such as route selection), tactical (driving manoeuvres and split-second responses to traffic) and operational (basic vehicle control) levels, was then used to structure and refine the CoDriS test content. As Michon's hierarchical model of cognition and driving behaviour delineates driving tasks into behaviours organised across hierarchical decision-making levels, it provided a sound framework for the theoretical blueprint, organising the content into constructs, knowledge requirements and cognitive domains.

3. Articulate the theoretical blueprint

The first two steps aid in articulating the theoretical blueprint during instrument development. Once the construct, purpose and rationale are known, and the appropriate empirical framework is established, test developers can create a blueprint, outlining the domain or content areas that are to be included in the instrument[3]. This is an iterative process and allows developers to tailor the instrument and enhance content validity during the instrument development[3]. Cognitive domains, the motivation for said domains and content areas were developed in relation to the construct and are presented below in Table I, page 3

Table I: Blueprint

Construct	Knowledge requirements	Cognitive domain	Michon's cognitive level
Trip planning: To assess an individual's ability to plan a trip and deal with unforeseen circumstances.	Orientation to time	Time orientation	Strategic
	Time calculation	Problem solving	Strategic
	Money management	Problem solving	Strategic
	Fuel calculation	Problem solving and decision making	Strategic
	Directions	Immediate verbal recall and working memory	Strategic
	Order a taxi	Following instructions	Strategic
Driving ability: To assess an individual's ability to navigate traffic while driving.	Identifying traffic signs	Object recognition and scanning	Tactical
	Visual memory	Delayed visual recall	Tactical
	Auditory memory	Delayed auditory recall	Tactical
	Find the traffic sign	Form constancy and figure ground	Tactical
	Intersections	Procedural memory	Tactical
	Landmark Navigation	Spatial orientation	Tactical
	Road rules	Semantic memory	Tactical
	Roadside Factors	Scanning and reasoning	Tactical
	Driving manoeuvre	Object recognition and procedural memory	Operation
Driving fitness: A combined score of the client's ability to plan a trip, deal with unforeseen circumstances and navigate traffic.	**Trip planning score + Driving ability score**		Strategic, tactical and operational
Insight: This assesses how the individual's perception about their driving ability compares to the performance in the assessment.	Self-assessment of driving ability	Self-awareness	Strategic
	Self-assessment of test performance	Self-awareness	Strategic
	Self-assessment score – Driving fitness score		Strategic

4. Synthesize content and scale development

Kalkbrenner[3] recommends that researchers generate a comprehensive pool of items based on the empirical framework and blueprint[3]. This exhaustive list is then reviewed to remove redundant items. Following this, the instrument is assembled, with careful consideration given to the measurement format and the scaling of response options.

Drawing on clinical experience, the first author initially developed informal, paper-based questions featuring images of traffic signs and traffic scenarios to assess cognitive domains relevant to driving, as well as driving knowledge and trip planning ability. To improve accessibility and standardisation, these questions were refined for online administration with automated scoring. The revised test items use multiple-choice and click-on-image formats, removing the need for verbal responses or fine motor dexterity. The online format directly captures responses, applies automated scoring algorithms to generate item and construct scores, reduces the need for assessor training, eliminates time required for manual score calculation and minimises potential administrator bias.

RESULTS

Administration

- The CoDriS is expected to take 20–50 minutes to complete, with the extended timeframe accommodating individual processing styles and potential cognitive impairment affecting thought processing speed.
- The CoDriS starts with an introduction that explains the purpose of the test and provides navigation instructions, including guidance on what assistance is allowed.
- This is followed by a demographic section that collects non-personal identifying information.
- Each CoDriS has a unique number stored in the database, which only the assessor and the individual performing the CoDriS can link to a name.
- Instrument administration and score interpretation documents are provided.

Content

- Insight is assessed through self-assessment questions where individuals rate their ability to manage specific trip conditions that match scenarios tested in the CoDriS. This allows

comparison between perceived and actual performance. Two versions of these questions are provided, one for active drivers and one for non-active drivers, using slightly different wording but identical content to maintain relevance and avoid confusion. Additionally, at the end of the CoDriS, individuals rate their overall test performance, providing further insight into their self-awareness, which can then be compared to their actual test scores.

- The CoDriS includes a range of test items designed to assess different cognitive domains and driving knowledge, using practical trip planning and traffic scenarios relevant to independent driving.
- While both Trip Planning and Driving Ability are important components of a comprehensive driving assessment, greater emphasis is placed on the individual's capacity to drive and navigate traffic. Consequently, the CoDriS includes more test items assessing Driving Ability than Trip Planning.
- The sequence of test items has been carefully structured to reduce the risk of interference between items, e.g. for those assessing delayed memory.

Language

- The instructions (currently in South African English) are clear and designed to address common assumptions or questions that may affect understanding.
- While individuals are encouraged to read the instructions themselves, assessors may read them aloud to accommodate varying literacy levels.
- Given South Africa's multicultural context with diverse language nuances, assessors are permitted to rephrase instructions up to twice to ensure comprehension is not hindered by language barriers.

Design

- Due to screen size, the CoDriS is recommended for use on computers or tablets, not smartphones.
- Each test item follows a consistent layout in heading, font, colour and size to maintain simplicity and avoid distraction.
- Apart from typing in their age, all test items use multiple-choice or click-on-image formats for easy, intuitive touchscreen use. The design simulates smartphone interaction to broaden accessibility beyond computer literacy. Individuals may receive help navigating the device, as long as they answer the questions themselves, to ensure unfamiliarity with the device doesn't affect their performance.
- Multiple-choice options are presented in sequential order (e.g. lowest to highest) to minimise cognitive load. When the question has no predetermined number of options (e.g. weekdays), four options are used for consistency.
- Each test item is designed to fit on a single screen. Items with multiple questions appear over several pages accessed by clicking "NEXT". For items not testing immediate recall, instructions are repeated on each page to ensure results reflect the intended cognitive domain rather than memory for instructions.
- Once "NEXT" is selected, the previous page becomes inaccessible. This ensures that information from subsequent test items, which measure different cognitive domains, cannot be used to answer earlier items.
- To mitigate interruptions from connectivity issues or accidental exits, the test can be resumed via a unique link, with previously completed scores saved. This also allows completion across multiple sessions if needed, though this is not recommended.

Construct scores

- Test responses are recorded upon selecting "NEXT" and automatically scored in the background database.
- Individual item scores are grouped to calculate construct scores: Trip Planning, Driving Ability, Driving Fitness, Self-Assessment and Insight.
- On completion of the CoDriS, a scoresheet is generated with item and construct scores alongside descriptive interpretations.
- Construct scores are presented as percentages for consistency and ease of comparison.

Score formulas

- A three-point Likert scale was selected for the Self-Assessment questions to avoid overwhelming individuals with cognitive impairment. For the seven driving-related items, response options are Never/No, Sometimes/Maybe and Always/Yes. For the test performance item, the options are Great, Average and Poor.
- Most items are multiple-choice with a single correct response.
- Orientation to time is evaluated using the device's date, day and time settings, with leniency buffers for time.
- Click-on-image scoring is more complex, with positive, neutral and negative points assigned per item to keep scores within set minimum (0) and maximum limits.

Score weighting

- After assigning scores to individual test items, their weighting within each construct was reviewed by examining the cognitive domain's relevance to driving, adjusting for repeated domains and benchmarking against standardised cognitive tests. Individual response scores were then refined accordingly.
- Driving Fitness (45 points) is a composite score combining Trip Planning (15 points) and Driving Ability (30 points), weighted to reflect greater importance of Driving Ability.
- Each self-assessment question is scored up to 2 points, for a total maximum score of 16.
- The Insight score is calculated by subtracting the Driving Fitness score from the Self-Assessment score. It can be a positive or negative score. The bigger the difference between these scores, the poorer the individual's insight.

CONCLUSION

The CoDriS is an online cognitive driving screening instrument under development within South Africa, combining assessments of cognitive domains with contextually relevant driving knowledge, using the MEASURE instrument development approach[3]. The first four steps of this framework have been completed, laying a solid foundation for continued instrument development. Further research addressing the remaining steps is needed to establish its validity and reliability.

Acknowledgements and Declaration

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