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Acceptability and usability of computerised cognitive assessment among Australian Indigenous residents of the Torres Strait Islands

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Key words: Neuropsychology, Epidemiology, Indigenous Health

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Abstract

Objectives: This cross-sectional study aimed to investigate the acceptability and usability of the Cogstate Brief Battery (CBB) in a community-based sample of Australian Indigenous people from the Torres Strait region, based on a User Experience framework of human-computer interaction.

Methods: Two hundred community participants completed the four subtests of the CBB on an iPad platform, during a free adult health check on two islands in the region, between October and December 2016. Acceptability was defined as completing the learning trial of a task and usability as continuing a task through to completion, determined by examiner acumen and internal Cogstate completion and integrity criteria. These were combined into a single dichotomous completion measure for logistic regression analyses. Performance, measured as reaction times and accuracy of responses, was analysed using linear regression analyses.

Results: CBB completion ranged from 82.0 - 91.5% across the four tasks and the odds of completing decreased with age. After adjusting for age, iPad/tablet familiarity increased the odds of completion for all tasks, while level of education and employment for some tasks only. These variables accounted for 18.0 - 23.8% of the variance in reaction times on speeded tasks. Age and education had the most effect, although semi-partial correlations were modest.

Conclusions: When administered in a health screening context, the acceptability and usability of the CBB were greatest in young to middle-aged participants with some education and iPad/tablet experience. Older and more vulnerable participants may have benefited from additional time and practice on the CBB prior to administration.

Key words/Mesh terms: Neuropsychology, Culture, Technology, Public Health, Psychology, Oceanic Ancestry Group

Introduction

In the field of neuropsychology there is growing awareness that neuropsychological expertise and decision making should be extended to individuals from culturally diverse populations including First Nations people (Mindt, Byrd, Saez, & Manly, 2010). Substantial efforts have already been made in understanding how cultural and linguistic issues can influence decisions about cognition based on performance on both standardized conventional neuropsychological tests adapted culturally and on neuropsychological tests developed for specific cultural assessment contexts (Ardila, 2005). One method shown to be useful in these developments has been to take neuropsychological tests with established validity and reliability in one or more cultural contexts and challenge the extent to which such properties extend to the Indigenous group of interest (Dingwall, Lewis, Maruff, & Cairney, 2009; D LoGiudice et al., 2006b).

While Australia has a high income per capita, its First Nations peoples, Aboriginal and Torres Strait Islander (Indigenous) Australians, have one of the poorest health profiles of Indigenous people worldwide (Hill, Barker, & Vos, 2007). Although poor health manifests as high mortality, there is also substantial morbidity arising from multiple systemic illnesses, including those involving the central nervous system (CNS). For example, the rates of dementia (Radford et al., 2015), stroke (Katzenellenbogen et al., 2011), and traumatic brain injury (Esterman et al., 2018) are two to five times higher among Indigenous Australians compared with other Australians. In developed countries, neuropsychological assessment and decision making is central to the identification, diagnosis and management of each of these conditions hence there is a need for neuropsychological tools appropriate for their management in Indigenous peoples.

Unfortunately, the majority of neuropsychological assessments validated for use in CNS conditions are limited in the extent to which they can be used to guide clinical decision-making in Indigenous contexts. Factors that limit this validity include wide-ranging levels of literacy and numeracy in these groups, differing understanding of cognitive constructs such as time and space that are implicit in assessment tools (Brickman, Cabo, & Manly, 2006), and different expectations and understanding about the aims and outcomes provided by neuropsychological assessment (Fletcher-Janzen, Strickland, & Reynolds, 2013). These factors are influenced further by demographic characteristics and access to, and history of, education (Brickman et al., 2006). The ethical use and correct interpretation of cognitive performance requires that neuropsychological tests assess abilities that are familiar to the examinee (Mindt et al., 2010). Hence, to ensure validity of neuropsychological assessment in First Nations people, candidate tests must be evaluated in the specific population for which it is intended (Mindt et al., 2010).

The Kimberley Indigenous Cognitive Assessment (KICA) (D LoGiudice et al., 2006a) tool is one test validated for use in Indigenous Australians, including those from the Torres Strait. The KICA is similar in design to the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) and was intended to assist in screening for dementia in Australian Indigenous people aged 45 years and over, predominately through assessing memory and language skills involving culturally appropriate everyday objects and pictures. However, the emphasis of the KICA on the detection of dementia limits severely its use in CNS condition where cognitive impairment is more subtle, especially in younger people. In this context, there is a need for tests of different aspects of cognition that can guide neuropsychological decision making across the lifespan.

One assessment designed for use in Australian aboriginal peoples is the Cogstate Brief Battery (CBB). The CBB was designed so performance on the tests was not constrained by cultural or linguistic characteristics of individuals being assessed. It consists of four tests that measure, psychomotor function, attention working memory and visual learning, each of which utilises playing-cards for stimuli. In studies in developed countries the CBB shows high sensitivity to cognitive dysfunction associated with dementia and mild cognitive impairment (Maruff et al., 2013), concussion (Louey et al., 2014), Type 2 diabetes (Macpherson et al., 2017) and HIV-associated neurocognitive disorder (Cysique, Maruff, Darby, & Brew, 2006). Among healthy and injured mainland Indigenous peoples, these same CBB tests show high usability and acceptability and satisfactory validity (Dingwall, Gray, McCarthy, Delima, & Bowden, 2017; Dingwall et al., 2009). With this background the CBB may also be appropriate for assessing cognition in people from the Torres Straits, who have their own distinct identity, history and cultural traditions (Dudgeon, Wright, Paradies, Garvey, & Walker, 2010).

Before determining the validity and reliability of cognitive tests in Indigenous groups it is necessary to determine their acceptability and usability in the groups of interest. One framework shown to be useful for determining the usability and acceptability of computerised cognitive tests in new contexts has been to modify approaches from the user experience (UX) models of human-computer interaction to conventional psychometric investigations (Darby et al., 2014). In the UX framework, acceptability is defined as the individual's evaluation of whether a program is useful, trustworthy and stable in relation to the domains in which it purports to operate (Shackel, 2009). In this same framework, usability is defined as the ability of a testing system to promote output consistent with the goals, aims and priorities of the system (Rosson & Carroll, 2002; Shackel, 2009). It is described using two dimensions: first, learnability reflects the ease with which the user can acquire, begin and enjoy using the system. Second, efficiency reflects the effectiveness with which a user can access and productively utilise the program with low error rates (Holzinger, 2005). For the CBB, learnability has been defined as the extent to which a test can be completed once begun. Efficiency has been defined as the extent to which performance on the test is consistent with that of other individuals, irrespective of their cultural or linguistic background who know and understand the rules and performance requirements of each test. As yet, neuropsychological research has not utilized UX principles in test development for use within culturally and linguistically diverse (CALD) groups.

The first aim of this study was to investigate the acceptability and usability of the CBB in a community-based sample of Australian Indigenous people from the Torres Strait region. This population currently does not have a cognitive assessment tool validated across the lifespan. The first hypothesis was that the CBB would show high acceptability and usability in this population. We then explored the extent to which these characteristics of test performance were related to age, education levels, employment status and familiarity with electronic devices. The second hypothesis was that for participants who could undertake CBB tasks in accordance with the rules and requirements, performance would decrease as a function of increasing age; again, we also explored the extent to which performance was associated with education, employment and familiarity with computers. This study also sought to comment on the suitability of the CBB in an Indigenous population health screening context, through qualitative observations and examining the average time for participants to complete a full assessment.

Methods

Study setting

Data for this study were collected during a community-based health screening program (Well Persons Health Check - WPHC), which occurred over thirteen days on two islands in the Torres Strait region between October and December 2016. Detailed information about the study setting, historical context and methodology is published elsewhere (Berger et al., 2018). The WPHC was conducted in collaboration between the Torres and Cape Hospital and Health Service and James Cook University (Zenadth Kes Health Partnership). Measures including socioeconomic information, cognition, depression, stress and pathology tests for chronic low-grade inflammation were collected to explore the association between the metabolic syndrome and other chronic conditions. The health check/researcher combined team comprised Indigenous Health Workers, medical doctors, nurses, dentists, mental health nurses and a provisional psychologist (FT). Ethical approval for this study was granted by the Far North Queensland Human Research Ethics Committee (HREC/16/QCH/70 – 1059).

Participants

Participants were community members aged 15 years and over who identified as Aboriginal and/or Torres Strait Islander. For the current CBB study, the inclusion criteria were for a participant to provide consent for both the Health Check and for the additional research measures. The exclusion criteria were (1) non-consent (n = 1), (2) insufficient responses to broader study questions (n = 3), (3) time constraints, (4) having a physical or sensory disability (e.g., hearing) preventing valid assessment and (5) having sole charge of a young child during the health check. A total of 214 participants were screened and met the inclusion criteria. A subset of 14 people met one or more of the exclusion criteria and were excluded from the study. In total, 200 participants were briefed and registered to take part in cognitive assessment.

Demographic data collection

Demographic data included age (years), sex (male, female), total years of education, employment status when of working age (15 - 64 years) defined as a person having a paid job (yes, no) and island of residence. Participants were also asked if they had ever used an electronic device such as iPad or tablet (yes, no), and what was their dominant hand (left, right).

Cogstate Brief Battery

The CBB was administered on an iPad platform, in English language, predominantly by the provisional psychologist (i.e., for 92% of participants). The time allocated for each CBB assessment, within the broader health check, was 16 minutes. This time was extended for participants who required additional explanation of instructions, or moved through assessment slower. However, there was insufficient time to provide additional practice tests. The locations of administration (n = 5) varied depending on availability of space within local facilities. Each location afforded visual privacy and was for the most part free of major noise disruption.

Participants were first briefed on the role of cognitive assessment within a comprehensive health check and encouraged to try their hardest on all assessment, although should not feel bad if any mistakes were made. Prior to each assessment, the examiner attempted to establish rapport with participants to improve acceptability and cultural safety. Each task was preceded by standard instructions, further accompanied by hand gestures representing the movements of cards. Both the participant and examiner used linked headphones during assessment to reduce background distractions and allow the examiner to follow participant progress. The examiner also observed and recorded participant engagement in the CBB subtests.

The Cogstate software has 'built-in' criteria to indicate completion of four tasks and integrity of responses on the tasks (Table 1). These criteria were applied to the data for each assessment. The CBB tasks were presented to each participant in the order described in Table 1. If a participant was unable to complete the practice phase for a specific task, based on examiner acumen, then the task was not undertaken and the practice phase for the next task was attempted (see Table 2).

Psychosocial assessment

Depressive symptoms were measured with the adapted Patient Health Questionnaire 9 (aPHQ-9), a screening instrument designed to measure depressive symptoms in primary care patients, which has been adapted for Aboriginal people in central Australia (Brown et al., 2013). A score between 10-27 indicates moderate to severe depressive symptoms (Kroenke, Spitzer, & Williams, 2001). Participants were referred to community mental health services if they reported self-harm ideation or scored ≥10 on the aPHQ-9 assessment.

INSERT TABLE 1 HERE

Study outcomes and data analysis

Acceptability was operationalised as a participant being able to complete and understand the learning trial of a task and then commence the actual assessment phase, based on examiner acumen. Usability was defined as continuing a task through to completion based on both examiner acumen and Cogstate completion criteria and Cogstate integrity criteria (i.e., a complete assessment). A task was deemed complete when a participant remained engaged in the task for the entire duration. Reasons for non-completion included losing focus, becoming disinterested/frustrated to the point of distraction, appearing to respond randomly and losing track of the task set (See Supplementary Table 1). For each of the four CBB tasks, the measures of acceptability and usability combined into a single measure of 'completeness' (i.e., the number of participants who had a complete assessment). These data are reported for the entire study sample in Table 2 and by participant characteristics in Table 3. As there were four subtests in the CBB, results in this manuscript are often reported as a range, to encompass the lowest and highest results across these tests.

The effect of demographic characteristics on CBB acceptability and usability was assessed with chi-square tests or Fisher's Exact Test as appropriate. To account for the ubiquitous effect of age, logistic regression analyses both unadjusted and adjusted for age were undertaken to determine whether other demographic characteristics remained associated with the odds of a complete task response (Table 4). Acceptability was also informally assessed based on qualitative observations by the primary examiner (FT) of the barriers to establishing an appropriate testing environment using Cogstate on an iPad platform.

The acceptability and usability data for One Back and One Card Learning tasks had sufficient cell size counts to conduct multivariate analyses in order to determine which demographic factors independently predicted completion of these complex tasks. The first model included age, sex, education and iPad/tablet experience. The second model was limited to participants of working age (i.e., 15 - 64 years) and included the same demographic variables, with the addition of employment status.

The second study outcome was the CBB performance (5 scores including $\log_{10}$ mean reaction time and arcsine-transformed proportion of correct responses on 4 CBB tasks, Table 5). The CBB performance was operationalised by assessing the effects of demographic characteristics on CBB performance among the participants with complete Cogstate results. For this, we conducted 5 separate linear regression analyses which were unadjusted and then adjusted in a hierarchical approach, first 'partially' for age, sex and education and then 'fully' for all demographic study variables. Semi-partial squared correlations using the 'pcorr' function in STATA were undertaken to determine the unique variance accounted for by each predictor variable. All quantative analyses were undertaken using STATA 14.0 (College Station, Texas). The suitability of Cogstate in an Indigenous population health screening context was assessed by examining the mean time in minutes to complete a full assessment for participants with a complete response on at least one task.

Results

Participant characteristics

The 200 participants who were briefed and registered to participate in cognitive assessment using the CBB were not significantly older (M = 40.6 years, SD = 16.9, range 15 - 78) than the participants who did not register (p = .218). Similarly, the registered group did not differ in terms of sex (44.5% male), education (30.1% tertiary level qualifications – including vocational and university courses) or employment (59.7% of working age participants employed) from the unregistered group. One third (31%) of the study group had never used an iPad/tablet previously and the average age of this group (M = 52.3 years, SD = 1.9) was significantly older compared with participants who had iPad/tablet experience (p < .001).

Cogstate acceptability and usability

In terms of acceptability, 1.5 - 11.0% of the 200 study participants were unable to attempt one of the four cognitive assessments (Table 2). The most common reasons were not understanding the task instructions or learning phase (*n* = 2 - 12) and inability to complete the learning phase once started (*n* = 4 - 9) (Supplementary Table 1). In terms of usability, a small proportion of those who commenced a task were unable to complete it (Table 2). The main reasons for this included: misunderstanding instructions (*n* = 1 - 6), distraction (*n* = 1), poor effort (*n* = 2) and unspecified reasons (*n* = 4 - 9). Non-completion was more common based on examiner observation (2.6 - 6.6%) than on Cogstate criteria (0.5 - 1.7%) (Table 2). Among participants who completed the assessment tasks, between 2 (1.2%) and 5 (2.7%) gave a pattern of response considered invalid based on Cogstate data integrity criteria.

After all of these completion and integrity exclusions were applied as a measure of acceptability and usability, 183 (91.5%) of the 200 eligible participants had a complete response for the Detection task, 181 (90.5%) for the Identification task, 164 (82.0%) for the One Card Learning task and 169 (84.5%) for the One Back task (Table 2). The majority of participants were able to complete all four Cogstate assessment tasks (*n* = 155, 77.5%) (results not tabled).

INSERT TABLE 2 HERE

Cogstate acceptability and usability by participant characteristics

The proportion of participants with a complete assessment was significantly lower in the older age groups ($p < .001$), among participants who had never used an iPad/tablet previously ($p < .001$) and those not in paid employment (Table 3). Lower levels of education were associated with a lower proportion of complete assessments for the One Card Learning task only.

INSERT TABLE 3 HERE

The odds of a complete assessment across each of the four CBB tasks was lower in the older age group, with the most pronounced effect among those aged 65 - 78 years (Table 4). After adjusting for age, participants with tertiary level education were three times more likely to have a complete assessment on One Card Learning, *OR* = 3.54; 95% CI 0.29 - 2.24, *p* = .011 and One Back tasks, *OR* = 3.33; 95% CI 0.09 - 2.32, *p* = .035, compared with participants whose highest education was some secondary schooling. Similarly, participants of working age who were employed and participants who had iPad/tablet experience were significantly more likely to have a complete assessment across all CBB tasks, after adjusting for age, compared with unemployed and iPad/tablet-naive participants.

INSERT TABLE 4 HERE

The One Card Learning task produced the lowest proportion (82%) of complete assessments (Table 2). In the first model adjusted for age, education and iPad/tablet experience, participants who had completed secondary school or tertiary education had odds of completing five times greater than participants who had not, *OR* = 5.19, 95% CI 1.15 - 23.47, *p* = .033 and *OR* = 5.23, 95% CI 1.21 - 22.5, *p* = .026, respectively. In addition, having previous exposure to an iPad/tablet, *OR* = 3.20, 95%CI 1.27 - 8.07, *p* = .014, was significantly associated with the odds of a complete One Card Learning assessment. In the second model, which adjusted for employment status and included only those of working age, the odds of a complete assessment were five times greater for employed participants, *OR* = 5.62, 95% CI 1.95 - 16.23, p<001.

When One Back task completion was examined with the same two models, increasing education and iPad/tablet experience resulted in significantly higher odds in the first model (results not tabled). When employment status was added as a covariate, being older reduced the likelihood of a complete assessment, while being employed and having iPad/tablet experience increased the odds, *OR* = 13.21, 95% CI 3.37 - 51.80, *p* < .001 and *OR* = 7.28, 95% CI 1.90 - 27.83, *p* = .004, respectively.

The time for a complete administration of the CBB ranged from 8m:59s up to 18m:25s (*M* = 12m:46s, *SD* = 2m:21s) and the times were normally distributed. Correlation and linear regression analyses indicated age in years was negatively associated with administration time, $r = -.313$, b = -0.043, $p < .001$ (results not tabled). The number of assessments administered on each day of the health screening ranged from 9 to 22 (*M*=14.1, *SD*=4.1).

Cogstate performance – reaction times and accuracy

Table 5 displays mean reaction times (RT), accuracy scores and results from univariate and multivariate linear regression analyses (beta coefficients, R^2) and semi-partial correlations (sr^2) for five demographic variables. Unadjusted linear regression analyses indicated that increasing age was associated with slower RT on all CBB tasks that assessed psychomotor reaction times (Table 5). Separate analyses indicated RT started to reduce around 40 years of age and were otherwise stable before that age (data not tabled). RT were generally faster, at a univariate level, among participants with higher levels education and iPad/tablet familiarity. These relationships remained after 'partial' adjustment for age, sex, education and iPad/tablet experience in multivariate analyses (Model 2, Table 5).

INSERT TABLE 5 HERE

The combined demographic variables, excluding employment status, accounted for a significant proportion of the variance in Detection speed, $F(6,176) = 6.40$, $R^2 = 18.0$, $p < .001$; Identification speed, $F(6,177) = 9.20$, $R^2 = 23.8$, $p < .001$ and One Back speed $F(6,163) = 7.38$, $R^2 = 21.4$, $p < .001$. Semi-partial correlation analyses presented in Table 5 indicated age and education accounted for the most unique variance in reaction time tasks, although these semi-partial correlations were modest, ranging from 9.8 - 13.2% for age and 2.3 - 4.9% for education.

Qualitative observations

Administration of the CBB was first trialled on the local community health check team. These residents provided feedback on culturally appropriate administration, including establishing rapport, using appropriate greetings (e.g., honorary titles), managing participant anxiety and accompanying instructions with hand movements. During the health check, most participants appeared to accept the CBB and no language barriers were evident. The visual memory (i.e., One Card Learning) task appeared particularly challenging and tedious for many participants. Participants appeared to appreciate the familiar playing card stimuli and headphones allowed background noise to be cancelled and participants to focus on testing. Participants suggested real playing cards could be used to assist with demonstrations. Practice sessions assisted with test comprehension and reduced testing anxiety. The examiner monitored the use of mobile phones and interruptions from animals and children. Some testing locations were particularly hot and humid and no air conditioning was available. The eldest participants appeared to have the most difficulty understanding test requirements and managing a touchscreen device. The CBB progresses from simple to more complicated tasks and this feature appeared particularly beneficial for participant engagement.

Discussion

This study followed a user experience (UX) framework to examine the acceptability and usability of the Cogstate Brief Battery (CBB) in a population of remote-living Indigenous Australians in a population health-screening context. Acceptability and usability were adequate (82.0 - 91.5%), in terms of the rate of participants who were able to complete CBB tests based on examiner observation and Cogstate criteria. Older and more vulnerable participants may have benefited from additional time and practice on the CBB prior to administration. Older age reduced the likelihood of participants completing all of the CBB tests, while years of formal education, experience with an iPad/tablet and having paid employment (among participants of working age 15 - 64 years) increased the likelihood of task completion. These demographic variables had varying and modest associations with reaction times on speeded tasks. While age and years of education had the strongest associations with speed, these variables only accounted for a modest proportion of unique variance in reaction time tasks (i.e., 9.8 - 13.2% and 2.3 - 4.9% respectively).

In terms of test completion, the rates in our study (82.0 - 91.5%) were lower than reported in studies of CBB tasks in non-Indigenous populations, (i.e. 97.6 - 97.3%) (Kataja et al., 2017; Mielke et al., 2015; Racine et al., 2016) and failed to support the first study hypothesis. The lower rates we observed may be related to two methodological aspects of the current study: the incorporation of examiner judgement and the limited time allocated for each CBB administration within the health screening context.

Regarding the first point, participants were excluded from the current analyses if unable to commence or complete tasks based on examiner observation (Supplementary Table 1), which was separate from inbuilt CBB completeness or integrity criteria. This preliminary step removed between 14 - 31 participants from analyses, producing a higher rate of ‘missing data’ compared to other studies that only relied on the inbuilt CBB criteria (Kataja et al., 2017; Mielke et al., 2015; Racine et al., 2016). These findings highlight the importance of examiner engagement in computerised cognitive assessment. This is particularly important in a context where computerised assessment and remotely delivered health care are both becoming more common.

Regarding the second methodological point, there was insufficient time to provide participants with additional practice tests during the health screen. It is likely that a greater number of older and vulnerable participants (i.e. with precluding medical conditions, lower computer literacy and lower education) would have had complete and valid assessments if provided additional time for explanations and practice on the CBB, prior to administration. This finding is not specific to use of CBB in individuals from the Torres Strait, or in other Australian Indigenous peoples. For example, a community-based health screen by Fredrickson et al. (2010) used a CBB completion definition that incorporated a 30-minute time limit. The rate of completion in that study was 85%, which was lower compared to other research (Kataja et al., 2017; Mielke et al., 2015; Racine et al., 2016). In a separate study of cognitively healthy community-dwelling educated older adults, computer literacy and precluding health conditions resulted in participants being unable to undertake assessment (Valdes, Sadeq, Harrison Bush, Morgan, & Andel, 2016). In these examples, providing opportunities for familiarity and practice may increase acceptability rates. The current study indicates that such strategies could be examined in future administration of the CBB in a Torres Strait population.

As older participants had the most difficulty with test completion, our study indicates that the CBB, delivered during a rapid health screen, does not have an optimal usability in this group. For older Indigenous people, tools such as the KICA (LoGiudice et al., 2006a; LoGiudice et al., 2011; Russell, Strivens, LoGiudice, Helmes, & Flicker, 2013) may be more useful for guiding decisions about CNS changes. Consistent with other research (Dingwall et al., 2017), our study highlights the need to establish more appropriate testing across the lifespan for Indigenous Australians at risk of cognitive decline.

Among participants with complete responses, responses times on CBB tests increased with age and decreased with more years of education. When demographic variables were combined, between 18.0 - 23.8% of the variance in reaction time tasks was explained, which supported the second study hypothesis and provided some indication of test validity. This is congruent with the size of demographic effect in neuropsychological testing in general (Heaton, Miller, Taylor, & Grant, 2004). In this population, it is important that the effects of education and employment status were ubiquitous. Indeed, more years of education and having paid employment were associated with faster reaction times irrespective of age. There is a long tradition of looking at employment status in neuropsychology research as a measure of independence in activities of daily living (Chelune, 1983). However, in specific populations employment may relate more to socio-economic opportunities than achieved education levels. This may be the case among Aboriginal and Torres Strait Island Australians and it is therefore important to consider this effect as a predictor rather than an outcome of cognitive functioning, similar to cognitive reserve indexes that have been proposed (Nucci, Mapelli, & Mondini, 2012). Multiple reasons have been suggested for why employment is linked with improved cognitive functioning (de Souza-Talarico et al., 2016), including increased social engagement, increased cognitive reserve, learning of new skills and maintenance of learnt skills, established routine/structure, income, perceived sense of purpose/meaning, and improved wellbeing (Vance, Bail, Enah, Palmer, & Hoenig, 2016). Employed individuals may also be more likely to understand the processes and expectations involved in cognitive assessment. It is also possible that those employed also had more familiarity with testing in general. The current results demonstrate the importance of considering these covariates when interpreting results in research studies and when establishing normative data. Furthermore, these factors would need to be adjusted for when using the CBB as a screening tool in order to accurately predict the presence and severity of cognitive deficits. The current study does not support the use of the CBB among Aboriginal and Torres Strait Islander Australians without such adjustments.

The CBB has many characteristics that make it accepted in populations where traditional tests are not appropriate (Dingwall et al., 2017). Compared with other standard neuropsychological tests, the CBB has had substantial validation in Indigenous Australians (Cairney, Clough, Jaragba, & Maruff, 2007; Dingwall, Lewis, Maruff, & Cairney, 2010) and has adequate reliability (Dingwall et al., 2009), depending on the specific task (Dingwall et al., 2017). Despite these advantages, the lower completion rates in the current study may be related to the cultural suitability of the CBB for the Torres Strait population. Cross-cultural neuropsychological models emphasise that assumptions used in the design of cognitive assessments in developed countries or high socio-economic populations do not operate in different cultural groups (Mindt et al., 2010). The results of the current study may indicate that even an instrument designed and validated for use in one group of Indigenous peoples (Dingwall et al., 2009) may still require refinement for use on others. Further studies with larger sample sizes and across different Australian Indigenous populations are needed to investigate this issue further.

The current study provides a sample of normative data for participants who were able to understand the rules and requirements of tests. While the dataset is small, it provides a valuable step in establishing the clinical utility of the CBB for screening of CNS disorders in this subpopulation of at-risk Indigenous Australians. For example, the rates of dementia are estimated to be almost five times higher (Strivens & Russell, 2017) among older Torres Strait residents compared with similar aged non-Indigenous Australians. The CBB could eventually be used to screen for subtle cognitive change in younger adults with conditions conferring higher risk, such as diabetes (Macpherson et al., 2017) and head injury (Louey et al., 2014).

In the current study, the CBB was suitable for brief cognitive assessment as part of a large community-based screening setting. The average administration time was around 15 minutes, including 3 minutes of introduction and debriefing post-test, which was comparable to previous research in an older (50+ years) healthy community cohort (M = 15.14 minutes) (Fredrickson et al., 2010) and adult Indigenous hospital patients (M = 13.28 minutes) (Dingwall et al., 2017). Qualitatively, Cogstate was versatile and a suitable testing environment could be established rapidly in multiple locations. Despite the practicality of the CBB for research purposes, the tool is currently not suitable for screening for disorders of the CNS in this Indigenous population in a general health screening context, given the lack of appropriate normative data and existing research.

In terms of limitations, the time constraints for each CBB administration likely contributed to the low completion rates. Excluding participants who have difficulty in understanding the test requirements may result in certain groups being underrepresented when using these types of cognitive screens within a broad health check context. This may also result in a sample only partially reflecting the population being studied, which may have occurred in the current study. As an example, participants with actual frank cognitive impairment may have been underrepresented in the study sample or, if present, discontinued early from assessment. As a result of time constraints. This study also did not include a formal assessment of how participants experienced the testing, which has been particularly informative in both Indigenous (Dingwall et al., 2017) and non-Indigenous settings (Mullen, Berry, & Zierler, 2004). There was also considerable overlap of demographic variables (e.g., older age overlapped with highest level of education) meant multivariate regressions were essential. Unfortunately, small cell sizes for the Detection and Identification tasks meant these types of analyses were not stable. Even when the One Card Learning and One Back task completions were assessed in multivariate models, confidence intervals for many of the estimates were extremely wide. A final limitation is that our study was cross-sectional and the CBB has been preferentially built for serial assessments. Previous research shows a substantial improvement in participant performance between first and second successive assessments as a result of increased understanding and test proficiency (Dingwall et al., 2009), which is important should a baseline for future testing be required.

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Table 1 - Description of the four Cogstate Brief Battery tasks used to assess cognition among 200 Torres Strait Islanders attending the 2016 Zenadth Kes Health Partnership health screen.

Cogstate Task	Description	Primary outcome measure(s)	Cogstate completion criteria	Cogstate integrity criteria
Detection	The participant attends to a card and presses either the *'Yes'* button with their right hand as fast as they can when the card turns face up and reveals a red joker. This is a reaction time task measuring visual attention and psychomotor function.	Reaction time, measured in log transformed milliseconds.	Participant responded to 75% of trials.	Accuracy of performance greater than 90%.
Identification	The participant attends to a card and when the card turns face up, presses *'Yes'* with their right hand if the card is a red joker or *'No'* with their left hand if the card is black joker. This is a choice reaction time task measuring visual attention.	Reaction time, measured in log transformed milliseconds.	Participant responded to 75% of trials.	Accuracy of performance greater than 70%.
One Card Learning	The participant attends to a deck of playing cards presented at the centre of the screen. When the top card turns face up, the participant presses *'Yes'* with their right hand if they have already seen that card in the deck of cards, or *'No'* with their left hand if they have not seen that card. Presented cards are 'reshuffled' back into the deck. This task measures visual memory and learning.	Accuracy, measured as the arcsine transformed proportion of correct responses of total cards presented.	Participant responded to 75% of trials.	Accuracy of responses greater than chance (i.e., 50%).
One Back	The participant attends to a deck of playing cards presented at the centre of the screen. When the top card turns face up, the participant presses *'Yes'* with their right hand if the presented card matches the previous card, and *'No'* with their left hand if the card does not match. Presented cards are 'reshuffled' back into the deck. This task measures working memory using an n-back paradigm.	Reaction time, measured in log transformed milliseconds. Accuracy, measured as the arcsine transformed proportion of correct responses of total cards presented.	Participant responded to 75% of trials.	Accuracy of performance greater than 70%.

Table 2 – Cogstate Brief Battery tasks used to assess cognition among 200 Torres Strait Islanders attending the 2016 Zenadth Kes Health Partnership health screen, by completion level and integrity

Task	Total	1 - Task attempted				2 - Task not completed				3 - Task completed		4 - Cogstate Integrity		5 - Complete			
		No		Yes[a]		Examiner[b]		Cogstate[c]		Yes[d]		Invalid[e]		No[f]		Yes[h]	
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)[g]	n	(%)[i]
Detection	200	3	(1.5)	197	(98.5)	11	(5.6)	1	(0.5)	186	(94.4)	3	(1.6)	17	(8.5)	183	(91.5)
Identification	200	9	(4.5)	191	(95.5)	5	(2.6)	1	(0.5)	186	(97.4)	5	(2.7)	19	(9.5)	181	(90.5)
One Card Learning	200	22	(11.0)	178	(89.0)	9	(5.1)	3	(1.7)	168	(94.4)	4	(2.4)	36	(18.0)	164	(82.0)
One Back	200	17	(8.5)	183	(91.5)	12	(6.6)	3	(1.6)	171	(93.4)	2	(1.2)	31	(15.5)	169	(84.5)

Notes: An additional 14 participants were screened during the health check and excluded from the current study due to meeting one or more exclusion criteria.

a. Number of participants who were able to complete the practice trial and commence the assessment task, as a proportion of Total Participants.

b. Number of participants who were observed to be incomplete or invalid based on examiner observation, as a proportion of all participants who commenced the assessment task.

c. Number of participants who were observed to be incomplete based on Cogstate criteria, as a proportion of all participants who commenced the assessment task.

d. Number of participants who completed the assessment task (i.e., participant commenced task and data were not missing based on Cogstate criteria and performance considered valid based on examiner observations).

e. Total participants who completed task with valid results based on examiner observation, however, results were considered invalid based on Cogstate Integrity criteria.

f. Total number of participants who did not have a complete or valid response (i.e., did not attempt task, or did not complete task, or task was invalid based on examiner observations or Cogstate Integrity criteria).

g. Total participants who did not have a complete or valid response, as a proportion of all (n = 200) study participants.

h. Total participants who had a complete and valid response (i.e., attempted and completed task and results were valid based on examiner observations and Cogstate Integrity criteria).

i. Total participants who had a complete and valid response, as a proportion of all (n = 200) study participants.

Table 3 – Characteristics of 200 Torres Strait Islanders attending the 2016 Zenadth Kes Health Partnership health screen, according to completion of the four Cogstate Brief Battery tasks, with chi-square/Fisher's Exact tests for row proportional differences

			Complete task response																			
			Detection					Identification					One Card Learning					One Back				
Characteristics	**Values**	**Total**	**No**	**(%)**	**Yes**	**(%)**	**P**	**No**	**(%)**	**Yes**	**(%)**	**P**	**No**	**(%)**	**Yes**	**(%)**	**P**	**No**	**(%)**	**Yes**	**(%)**	**P**
Demographics	**All participants**	**200**	**17**		**183**			**19**		**181**			**36**		**164**			**31**		**169**		
Site	Remote Island	**96**	10	(10.4)	86	(89.6)	.350	12	(12.5)	84	(87.5)	.164	21	(21.9)	75	(78.1)	.171	18	(18.8)	78	(81.3)	.222
	Central Island	**104**	7	(6.7)	97	(93.3)		7	(6.7)	97	(93.3)		15	(14.4)	89	(85.6)		13	(12.5)	91	(87.5)	
Gender	Male	**89**	5	(5.6)	84	(94.4)	.191	10	(11.2)	79	(88.8)	.453	14	(15.7)	75	(84.3)	.454	16	(18.0)	73	(82.0)	.386
	Female	**111**	12	(10.8)	99	(89.2)		9	(8.1)	102	(91.9)		22	(19.8)	89	(80.2)		15	(13.5)	96	(86.5)	
Age (years)	15-24	**47**			47	(100.0)	.000	2	(4.3)	45	(95.7)	.000	1	(2.1)	46	(97.9)	.000	1	(2.1)	46	(97.9)	.000
	25-44	**73**	3	(4.1)	70	(95.9)		3	(4.1)	70	(95.9)		12	(16.4)	61	(83.6)		8	(11.0)	65	(89.0)	
	45-64	**63**	7	(11.1)	56	(88.9)		7	(11.1)	56	(88.9)		14	(22.2)	49	(77.8)		14	(22.2)	49	(77.8)	
	65-84	**17**	7	(41.2)	10	(58.8)		7	(41.2)	10	(58.8)		9	(52.9)	8	(47.1)		8	(47.1)	9	(52.9)	
Education	Primary-Some Second	**74**	10	(13.5)	64	(86.5)	.151	11	(14.9)	63	(85.1)	.089	21	(28.4)	53	(71.6)	.010	16	(21.6)	58	(78.4)	.093
	Complete second	**63**	3	(4.8)	60	(95.2)		4	(6.3)	59	(93.7)		7	(11.1)	56	(88.9)		9	(14.3)	54	(85.7)	
	Tertiary	**61**	4	(6.6)	57	(93.4)		3	(4.9)	58	(95.1)		7	(11.5)	54	(88.5)		5	(8.2)	56	(91.8)	
Employment	No	**73**	8	(11.0)	65	(89.0)	.016	7	(9.6)	66	(90.4)	.104	18	(24.7)	55	(75.3)	.001	18	(24.7)	55	(75.3)	.000
	Yes	**108**	2	(1.9)	106	(98.1)		4	(3.7)	104	(96.3)		8	(7.4)	100	(92.6)		4	(3.7)	104	(96.3)	
Other factors																						
aPHQ-9 (refer)	No	**179**	14	(7.8)	165	(92.2)	.315	17	(9.5)	162	(90.5)	.997	30	(16.8)	149	(83.2)	.183	26	(14.5)	153	(85.5)	.266
	Yes	**21**	3	(14.3)	18	(85.7)		2	(9.5)	19	(90.5)		6	(28.6)	15	(71.4)		5	(23.8)	16	(76.2)	
Used iPad/Tablet	No	**61**	15	(24.6)	46	(75.4)	.000	15	(24.6)	46	(75.4)	.000	22	(36.1)	39	(63.9)	.000	23	(37.7)	38	(62.3)	.000
	Yes	**138**	2	(1.4)	136	(98.6)		3	(2.2)	135	(97.8)		13	(9.4)	125	(90.6)		7	(5.1)	131	(94.9)	
Dominant hand	Left	**18**	1	(5.6)	17	(94.4)	.639	2	(11.1)	16	(88.9)	.807	4	(22.2)	14	(77.8)	.747	4	(22.2)	14	(77.8)	.491
	Right	**182**	16	(8.8)	166	(91.2)		17	(9.3)	165	(90.7)		32	(17.6)	150	(82.4)		27	(14.8)	155	(85.2)	

*Note: p=Fisher's Exact when Total number of cases <20, expect cases in any cell <=20 and >25% of cells have expected frequencies <5. *Employment status limited to people of working age (i.e., 15-64 years). aPHQ-9 (refer) = Patient referred for community mental health services based on reporting self-harm ideation or a score of ≥10 on the adapted Patient Health Questionnaire 9.*

Table 4 – Odds ratios [OR (95% CI)] for the association between participant characteristics and Cogstate Brief Battery task completion, among 200 Torres Strait Islanders attending the 2016 Zenadth Kes Health Partnership health screen.[$]

		Complete and Valid Task							
		Model 1					Model 2		
Characteristics		**No**	**Yes**	**OR**	**(95%CI)**	**p**	**OR**[a]	**(95%CI)**	**p**
DETECTION		**17**	**183**						
Age	15-24	0	47	-		-			
	25-44 (Reference)	3	70	1.00					
	45-64	7	56	0.34	(-2.47 , 0.33)	.133			
	65-78	7	10	0.06	(-4.30 , -1.29)	<.000			
Sex	Male	5	84						
	Female	12	99	0.49	(-1.79 , 0.37)	.198	0.45	(-1.98 , 0.39)	.191
Education	Primary-Some	10	64		(0.00 , 0.00)				
	Completed secondary	3	60	3.12	(-0.20 , 2.48)	.095	2.40	(-0.58 , 2.33)	.239
	Tertiary	4	57	2.23	(-0.41 , 2.01)	.196	1.76	(-0.78 , 1.91)	.409
Employed	No	8	65						
	Yes	2	106	6.52	(0.30 , 3.46)	.020	8.57	(0.53 , 3.77)	.009
iPad/tablet	No	15	46						
	Yes	2	136	22.17	(1.59 , 4.61)	<.000	9.15	(0.63 , 3.80)	.006
IDENTIFICATION		**19**	**181**						
Age	15-24	2	45	0.96	(-1.86 , 1.79)	.969			
	25-44 (Reference)	3	70	1.00					
	45-64	7	56	0.34	(-2.47 , 0.33)	.133			
	65-78	7	10	0.06	(-4.30 , -1.29)	<.000			
Sex	Male	10	79						
	Female	9	102	1.43	(-0.59 , 1.31)	.455	1.59	(-0.53 , 1.46)	.363
Education	Primary-Some	11	63		(0.00 , 0.00)				
	Completed secondary	4	59	2.58	(-0.25 , 2.14)	.122	2.17	(-0.49 , 2.03)	.228
	Tertiary	3	58	3.38	(-0.11 , 2.54)	.072	3.37	(-0.15 , 2.58)	.081
Employed	No	7	66						
	Yes	4	104	2.76	(-0.25 , 2.28)	.117	3.26	(-0.10 , 2.47)	.072
iPad/tablet	No	15	46						
	Yes	3	135	14.67	(1.40 , 3.97)	<.000	7.64	(0.66 , 3.41)	.004
ONE CARD LEARNING		**36**	**164**						
Age	15-24	1	46	9.05	(0.13 , 4.28)	.038			
	25-44 (Reference)	12	61	1.00					
	45-64	14	49	0.69	(-1.23 , 0.48)	.394			
	65-78	9	8	0.17	(-2.88 , -0.61)	.003			

Sex	Male	14	75						
	Female	22	89	0.76	(-1.02 , 0.46)	.455	0.78	(-1.02 , 0.53)	.536
Education	Primary-Some	21	53		(0.00 , 0.00)				
	Completed secondary	7	56	3.17	(0.22 , 2.09)	.016	3.02	(0.12 , 2.09)	.029
	Tertiary	7	54	3.06	(0.18 , 2.05)	.019	3.54	(0.29 , 2.24)	.011
Employed	No	18	55						
	Yes	8	100	4.09	(0.51 , 2.30)	.002	5.49	(0.76 , 2.64)	<.000
iPad/tablet	No	22	39						
	Yes	13	125	5.42	(0.92 , 2.47)	<.000	3.02	(0.24 , 1.97)	.012
ONE BACK		**31**	**169**						
Age	15-24	1	46	5.66	(-0.38 , 3.85)	.108			
	25-44 (Reference)	8	65	1.00					
	45-64	14	49	0.43	(-1.79 , 0.10)	.081			
	65-78	8	9	0.14	(-3.18 , -0.77)	.001			
Sex	Male	16	73						
	Female	15	96	1.40	(-0.43 , 1.11)	.387	1.59	(-0.37 , 1.29)	.274
Education	Primary-Some	16	58		(0.00 , 0.00)				
	Completed secondary	9	54	1.66	(-0.39 , 1.40)	.271	1.39	(-0.65 , 1.31)	.510
	Tertiary	5	56	3.09	(0.06 , 2.20)	.039	3.33	(0.09 , 2.32)	.035
Employed	No	18	55						
	Yes	4	104	8.51	(1.01 , 3.27)	<.000	13.15	(1.38 , 3.78)	<.000
iPad/tablet	No	23	38						
	Yes	7	131	11.33	(1.51 , 3.35)	<.000	6.16	(0.82 , 2.81)	<.000

Note: ORs calculated using logistic regression. Model 1 univariate only, Model 2 adjusted for age.

Table 5 – Beta, *p* values and semi-partial squared correlations for the association between participant characteristics and Cogstate Brief Battery task performance, among 200 Torres Strait Islanders attending the 2016 Zenadth Kes Health Partnership health screen.[$]

Characteristic	Values			Model 1		Model 2		Model 3			Semipartial	
		n	Mean	b	p	b	p	b	p	r^2	sr^2	p
Detection Speed												
Age	Years	183		0.002	<.000	0.002	<.000	0.002	<.000	0.203	10.7	<.001
Sex	Male	84	2.54								1.53	.085
	Female	99	2.52	-0.013	.341	-0.018	.171	-0.029	.021			
Education	Up to	64	2.55								1.20	.127
	Secondary	60	2.51	-0.044	.009	-0.048	.003	-0.050	.001			
	Tertiary	57	2.53	-0.027	.116	-0.040	.015	-0.022	.164			
iPad/tablet use	No	46	2.57									
	Yes	136	2.52	-0.048	.003	-0.022	.193	-0.002	.908		0.03	.824
Employed	No	65	2.54									
	Yes	106	2.51	-0.032	.017			-0.052	<.000		5.90	.001
Identification Speed												
Age	Years	181		0.002	<.000	0.002	<.000	0.002	<.000	0.194	13.2	<0.001
Sex	Male	79	2.71								1.76	.066
	Female	102	2.69	-0.019	.051	-0.024	.006	-0.021	.017			
Education	Up to	63	2.71								2.26	.037
	Secondary	59	2.68	-0.035	.002	-0.038	<.000	-0.035	.001			
	Tertiary	58	2.69	-0.019	.105	-0.030	.004	-0.022	.047			
iPad/tablet use	No	46	2.72								0.16	.572
	Yes	135	2.69	-0.027	.013	-0.001	.945	0.003	.792			
Employed	No	66	2.70								1.93	.054
	Yes	104	2.69	-0.009	.338			-0.022	.018			
One Back Speed												
Age	Years	169		0.002	<.000	0.002	<.000	0.002	<.000	0.159	9.8	<0.001
Sex	Male	73	2.85								0.02	.855
	Female	96	2.86	0.005	.692	-0.004	.763	-0.001	.963			
Education	Up to	58	2.88								4.94	.003
	Secondary	54	2.84	-0.043	.009	-0.040	.008	-0.042	.009			
	Tertiary	56	2.85	-0.032	.046	-0.049	.001	-0.049	.004			
iPad/tablet use	No	38	2.89									
	Yes	131	2.85	-0.042	.008	-0.011	.466	-0.012	.473		0.19	.561
Employed	No	55	2.84									
	Yes	104	2.85	0.011	.447			-0.001	.960		0.01	.911

One Back Accuracy												
Age	Years	169		-0.001	.178	-0.001	.140	-0.002	.073	0.050	1.9	.083
Sex	Male	73	1.32								0.27	.509
	Female	96	1.33	0.008	.729	0.008	.741	0.013	.604			
Education	Up to	58	1.32								2.45	.049
	Secondary	54	1.32	0.004	.879	0.004	.877	0.013	.668			
	Tertiary	56	1.35	0.037	.194	0.046	.112	0.065	.046			
iPad/tablet use	No	38	1.30								0.31	.484
	Yes	131	1.34	0.031	.259	0.013	.677	0.020	.539			
Employed	No	55	1.34								0.05	.781
	Yes	104	1.32	-0.012	.632			-0.010	.713			

Note: Beta, *p* values and semi-partial squared correlations calculated using linear regression. Model 1 univariate only; Model 2 adjusted for age, gender, education and iPad/tablet experience; Model 3 limited to working age participants only (i.e., 15-64 years) and adjusted for age, gender, education, iPad/tablet and employment status