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Adaptation Processes of Neuropsychological Test Battery for Children: Systematic Literature Review

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Abstract

When appropriately adapted to cultural contexts, neuropsychological tests may provide tools for psychologists and clinicians. Numerous researches have explored the adaptation and validation of neuropsychological tests for adults in Indonesia, however, a notable gap exists related to the development and validation of such instruments for children. The research aimed to explore potential tests as the initial stage of developing the Indonesian Neuropsychological Test for children. A systematic literature review, using PRISMA guidelines, was conducted to identify studies that reported adaptation of neuropsychological test batteries for children. The search was focused on two databases, PubMed and ScienceDirect, using the keyword "Neuropsychological Test Battery Development in Children". An initial electronic search found 4209 publications from 2003 to 2023. In the initial stage, automated screening excluded 752. Subsequent screening excluded reviews, book chapters, or those that did not involve neuropsychological test instruments, resulting in the elimination of 3435 articles. A full-text assessment led to the exclusion of 32 studies due to their study design, lack of reported adaptation findings, or a focus on non-comprehensive test batteries. Eight studies were included in the final analysis. Based on the literature reviews, several cognitive domains were commonly assessed using neuropsychological test battery, including memory, attention, executive functions, language, and sensory/psychomotor skills. Two neuropsychological test batteries have been developed in Asia, that reported satisfactory psychometric properties and cultural adaptation, making them suitable for their respective contexts. Therefore, the current study is expected to be a new stepping stone in validating Neuropsychological Test Battery for Children in Indonesia.

Keywords: Neuropsychology, Test Battery, Children, Systematic Literature Review

Introduction

In recent decades, research in neuropsychology has experienced remarkably rapid growth. The field of neuropsychological has been expanded beyond the pathological conditions of adult patients to capture a more comprehensive examination of human developmental profiles. Anderson et al. (2018), in their book titled "Developmental Neuropsychology: A Clinical Approach," highlight that the advancement of neuropsychological science across the countries is increasingly being applied in clinical practice to assess development in more detailed manner from

childhood onwards. Furthermore, the development of novel instruments has been undertaken in numerous countries to facilitate the assessment, intervention, and management of neuropsychological conditions relevant to children. Neuropsychology, as defined by the APA Dictionary of Psychology, is a branch of science which focuses on the nervous system and its connections to behavior and cognitive abilities. More specifically, this field investigates both the typical functions of the nervous system and the dysfunctions that arise from brain damage or neurological conditions.

Rooted in its scientific foundation back to the early 19th century, neuropsychology has evolved into an independent and well-established discipline (Sala, 2021). In essence, neuropsychology seeks to explore the complex interplay between brain function, cognition, behavior, and related phenomena (Berlucchi, 2009). Taking into account the main scope of neuropsychology as a science branch, sufficient assessment tools are highly needed. Neuropsychological assessment, according to Stebbins (2007), employs two primary approaches in practical settings: quantitative and qualitative. The quantitative approach, which is widely developed globally, involves the use of standardized assessment techniques, the results of which can be compared against established norms to obtain precise outcomes and interpretations. Specifically within the domain of developmental neuropsychology, a sub-discipline focused on children, the measurement of brain mechanisms underlying performance, alterations in brain function, and the profile of neurocognitive functions (Uecker, 2014). Uecker further emphasizes the responsibility of researchers and practitioners in developmental neuropsychology to provide up-to-date measurement tools capable of informing interventions that positively impact healthy brain development.

The practical application of neuropsychological assessments for children necessitates the inclusion of multiple cognitive domains, often complemented by supplementary measurement tools, as outlined in Baron's (2018) "Neuropsychological Evaluation of The Child: Domains, Methods, and Case Studies." Baron emphasizes the need to assess intellectual functioning alongside specific domains crucial for understanding a child's neuropsychological developmental profile. These key domains encompass executive functions (including working memory, inhibition and interference control, planning and set shifting, and verbal fluency); attention and processing speed (including focus and selective attention, divided attention, sustained attention, task shifting, and cognitive control); language (including aphasia screening tests, phonological processing, naming, receptive and expressive language, and auditory perception); motor examination (including handedness, handwriting, right-left orientation, praxis and apraxia, motor speed,

dexterity, coordination, and psychomotor problem solving); sensory-perceptual examination; visuospatial abilities; and learning and memory (including verbal and non-verbal learning and memory).

While various instruments have been developed to measure these domains across different languages, numerous studies highlight the importance of adapting assessment tools to the specific language and cultural context of a given country to minimize cultural bias and enhance the accuracy of the assessed profile (Fernández & Abe, 2018; Clikeman & Ellison, 2009). The development of culturally unbiased test instruments can involve various strategies. However, in the context of test adaptation, as conducted in several previous research, careful consideration of the appropriateness of measurement tools is paramount for accurately revealing the relevant profile (Semrud-Clikeman et al., 2017). Hence, the current study acted as a pilot project aimed at the instrument selection of pre-existing neuropsychological assessment tools for children that is feasible to be culturally and linguistically adapted for Indonesian children.

Method

The methodology of this systematic literature review is based on the principles outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model. Thus, a comprehensive search strategy was employed, and articles were retrieved from two reputable academic databases: PubMed and ScienceDirect. Conveniently, only journal articles written in English and published between 2003 - 2023 were selected for the initial phase. To ensure the retrieval of literature that directly addresses the research question, specific keywords were employed, namely "Neuropsychological Test Battery Development in Children". These methods aimed to capture a broad yet relevant pool of articles on the development of neuropsychological test batteries specifically designed for pediatric populations.

According to the PRISMA design, following the initial identification phase, the screening phase conducted. During this stage, the titles and abstracts were carefully examined for relevance to the study's objectives. Subsequently, remaining reports were sought for full-text retrieval, then underwent a thorough assessment for eligibility. Ultimately, eligible reports were excluded for various reasons, including not reporting adaptation results or psychometric properties, not investigating a full battery, or not being in the adaptation phases. Consequently, final selected studies which met all the inclusion criteria and were included in this systematic review.

Results

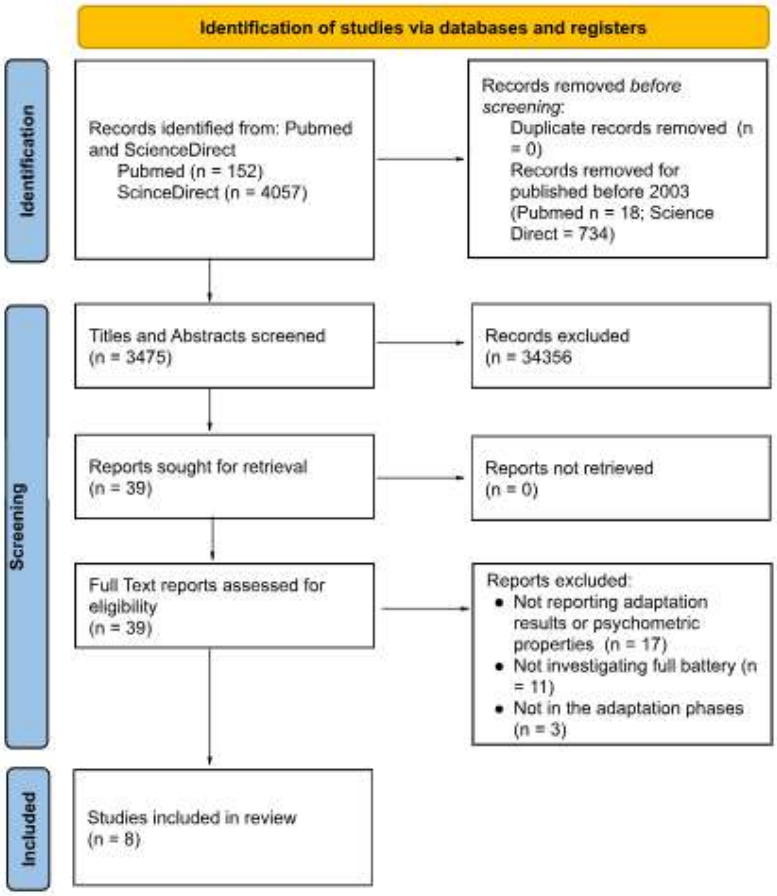

Figure 1. PRISMA Flow Diagram

The initial database search resulted in a substantial number of records, with 152 articles identified from PubMed and 4057 articles from ScienceDirect. Following the initial identification phase, a rigorous screening process was implemented to refine the selection of articles for inclusion in the review. Before the formal screening of titles and abstracts, several records were removed based on predefined criteria. Specifically, zero duplicate records were identified and removed at this stage. Additionally, a significant number of records (PubMed n = 18; ScienceDirect n = 734) were excluded as they were published before the year 2003, establishing a temporal boundary for the included literature.

After the initial removal of duplicates and older publications, the titles and abstracts of 3,475 distinct records were carefully reviewed. This initial screening led to the exclusion of 3,436 records whose titles and abstracts did not align with the study's focus. Consequently, 39 potentially relevant reports were identified and their full texts were retrieved. These 39 full-text reports were

then subjected to a more detailed eligibility assessment. This in-depth evaluation resulted in the exclusion of additional studies because they either didn't report adaptation outcomes or psychometric data (n = 17), didn't examine a comprehensive set of neuropsychological tests (n = 11), or didn't concentrate on the adaptation stages of test development (n = 3). In the end, 8 studies satisfied all the specified criteria and were included in the final analysis of this systematic review.

Code	Author and Year of Publication	Name of Test Battery	*Dataset*	Domains and Subtests
1	Davidson et.al. (2006)	Rochester Test Battery (*non-computerized*)	Healthy individuals aged 9-16 years (n=293; M=12.03)	1. Auditory Central processing - Pitch Pattern Sequence Test - CEST 2. Auditory Electriphysiology - Audiometry - Tympanometry - Otoacoustic Emissions - BAER - Dichotic Digits Test-Double Pairs 3. Visual Electrophysiology - VEPs - CPT **4. Neuropsychological Experiment Tests** - CANTAB (*The Cambridge Neuropsychological Test Automated Battery*) **The RTB (*Rochester Test Battery*) berisi beberapa sub-tes, yaitu:** **(a) delayed match to sample,** **(b) paired associate learning,** **(c) big/little circle,** **(d) intra-dimensional/extra-dimensional shift, and** **(e) reaction time.** - FI Self-control 5. Semosorimotor Experiment Test - Fine Motor Control - Scotopic Visual Form Discrimination - Visual Spatial Contrast Sensitivity
2	Clark et.al. (2006)	Integneuro Test Battery (*computerized*)	Healthy individuals aged 6-82 years (n=1007)	1. Sensori-Motor - Motor Tapping (Adaptasi dari Finger Tapping Test) - Choice Reaction Time Test 2. Memori dan Belajar - Memory Recall and Recognition Test (Adaptasi dari RAVLT) - The Maze Task (Adaptasi dari Austin Maze Task; Computerized) 3. Bahasa - Letter Fluency (Adaptasi dari COWA: F,A,S) - The Spot Real Word (Adaptasi dari Spot the Word Test) 4. Atensi dan Working-Memory

				- The Span Visual Memory Task (Adaptasi Corsi Block Task dan Dot Location Task) - Bagian 1 Switching of Attention/SOA (Adaptasi dari TMT-A) - Time Estimation Task (Estimasi durasi kemunculan stimuli berwarna) - To Tap Sustained Attention - Digit Span (forward dan reverse) - Bagian 1 Word Interference Test (Adaptasi dari Stroop Task) 5. Fungsi Eksekutif dan Perencanaan - Bagian 2 Switching of Attention/SOA (Adaptasi dari TMT-B) - Bagian 2 Word Interference Test - Maze Task
3	Lee et.al. (2021)	Korean Computerized Neurobehavioral Tests (*computerized*)	Healthy individuals aged 7-8 years (n=254)	1. Waktu Respon - Simple Reaction Time 2. Kecepatan Psikomotor - Choice Reaction Time (Instruksi: Menekan tombol panah sesuai arah gambar panah yang muncul di layar) 3. Atensi - Color Word Vigilance (Instruksi: Menekan tombol secepat mungkin saat warna dan arti yang cocok muncul di layar) 4. Fungsi Eksekutif - Addition - Symbol Digit 5. Ketangkasan Tangan - Finger Tapping Speed
4	Nitzburg et.al. (2014)	MATRICS cognitive consensus battery (*non-computerized)*	Healthy individuals aged 8-23 years (n=190)	1. Kecepatan Pemrosesan - Symbol Coding (diambil dari Brief Assessment of Cognition in Schizophrenia) - Trail Making Test-A - Category Fluency-Animal Naming 2. Atensi dan Vigilance - Continuous Performance Test-Identical Pairs 3. Working Memory - Wechsler Memory Scale-Spatial Span - Letter Number Span 4. Verbal Learning - Hopkins Verbal Learning-Revised 5. Visual Learning - Brief Visuospatial Memory Test-Revised 6. Reasoning dan Pemecahan Masalah - Neuropsychological Assessment Battery-Mazes
5	Rohitrattana et.al.,	Behavioral Assessment	Healthy individuals	1. Response Speed and Coordination

	2014	and Research System (BARS) (*computerized & non computerized*)	aged 5 years 10 months - 8 years 11 months (n=24)	- Computerized Finger Tapping/TAP 2. Divided Attention - Divided Attention/DAT 3. Dexterity - Purdue Pegboard/PEG 4. Hand-Eye Coordination - Visual Motor Integration/VMI 5. Memory and Attention - Digit Span/DST 6. Recall & Recognition Memory - Object Memory Test/OMT 7. Information Processing Speed - Computerized Symbol Digit/SDT 8. Visual Memory - Computerized Match to Sample/MTS 9. Sustained Attention - Computerized Continuous Performance/CPT
6	Smerbeck et.al., 2012	Neuropsychological Battery for Pediatric Multiple Sclerosis (*non-computerized*)	Healthy individuals aged 5-18 years (n=102; M=11.8) and individuals with a diagnosis of MS aged 9-18 years (n=51; M=15.2)	1. Intelligence - WASI (Wechsler Abbreviated Scale of Intelligence: Subtes Vocabulary dan Matrix Reasoning 2. Sensorymotor - Grooved Pegboard Test/GPT 3. Language - Expressive One Word Picture Vocabulary Test/EOWWPVT - DKEFS Verbal Fluency 4. Spatial-Visual Speed - Beery-Buktenika Test of Visual Motor Integration/VMI 5. Memory and Learning - California Verbal Learning Test for Children 6. Executive Function - Conners Continuous Performance Test-2nd Edition/CPT II - WISC-IV: Digit Span - WISC-IV: Coding B - Contingency Naming Test - DKEFS Trail Making Test A dan B
7	Wallace et.al. 2023 (pre-print)	National Institute of Health (NIH) Toolbox Cognition and Emotion Batteries (*computerized*)	Individuals aged 6-17 years (CHD patients n=58 and Healthy/Control n=80)	1. Crystallized Cognition Subtest - Oral Reading Recognition Test/ORRT - Picture Vocabulary Test/PVT 2. Fluid Cognition Subtest - List Sorting Working Memory Test/LSWMT - Pattern Comparison Processing Speed Test/PCPST

				- Flanker Inhibitory Control and Attention Test/FIC+AT - Dimensional Change Card Sort Test Executive Function/DCCST - Picture Sequence Memory Test/PSMT
8	Portaccio et.al. 2009	Brief Neuropsychological Battery for Children (BNBC) with MS (*non-computerized*)	Individuals aged 6-17 years (CHD patients n=58 and Healthy/Control n=80)	1. Inteligence - WISC-R 2. Verbal Learning and Delayed Recall - Selective Reminding Test/SRT and Delayed SRT 3. Visuospatial Learning and Delayed Recall - Spatial Recall test/SPART and Delayed SPART 4. Sustained Attention and Concentration - Symbol Digit Modalities Test/SDMT - Trail Making Test A dan B 5. Abstract Reasoning - Modified Card Sorting Test 6. Expressive Language - Semantic-Phonemic Verbal Fluency Test - Oral Denomination Test 7. Receptive Language - Token Test - Indication of Pictures - The Phrase Comprehension

Discussion

This research is part of an ongoing longitudinal study to develop a Neuropsychological Test Battery for Indonesian Children. Specifically, this research represents the first stage (initial study/pilot project) in a test instrument adaptation process, namely the selection process of neuropsychological test instruments that have been developed by previous researchers. In developing psychological tests, particularly neuropsychological tests, several criteria must be considered, namely:

1. psychometric properties reported by previous researchers, namely the validity and reliability of the test instrument;
2. implementation of the validation process in clinical settings, particularly related to reporting the sensitivity and specificity levels of the developed neuropsychological test;
3. applicability (ease of application) related to the language, culture, and educational level for which the test is adapted;
4. having subtests that can address domains that measure different cognitive functions.

Based on the results of the initial study using the literature review method, the following findings can be concluded:

1. Psychometric Properties:

Neuropsychological test adaptation studies that have reported psychometric property analysis results are:

1.1. Korean Computerized Neurobehavioral Tests (KCNT). This study aimed to measure the reliability of neurobehavioral tests for children in Korea. Participants in this study were 254 healthy children, aged 7-8 years. Psychometric properties were measured using the test-retest method, with the Pearson product-moment correlation coefficient (r) and the intraclass correlation coefficient (ICC) as standard analyses. The KCNT test battery contains a series of tests to measure: Simple Reaction Time, Choice Reaction Time, Color Word Vigilance, Addition, Symbol Digit, and Finger Tapping Speed. The results of the KCNT psychometric property analysis are as follows: (a) The ICCs ranged from 0.46 to 0.84 (according to standard Pearson coefficients). High reliability was found for the Symbol Digit (r = 0.84, ICC = 0.83), followed by the Finger Tapping Speed for measuring dominant hand usage (r = 0.67, ICC = 0.67) and the non-dominant hand (r = 0.65, ICC = 0.65). The results of this KCNT development study indicate that this test can be used in a neurobehavioral test battery for assessing children in Korea.

1.2. The Behavioral Assessment and Research System (BARS) adapted for use in Thailand . This study adapted a neuropsychological test covering the following aspects: motor speed and dexterity, attention, memory, and visuospatial coordination. The study involved 24 healthy children aged 6-8 years in urban Thailand. Psychometric properties were measured using the test-retest method with an alternate form. The comparison group involved 29 other healthy participants living in rural Thailand. Test-retest analysis results ranged from 0.41 to 0.77 (Pearson coefficient), while reliability achieved on the alternate form was relatively low and variable (0.11 to 0.83). The results of this initial development study of the Thai neuropsychological test battery indicate that the sensitivity of this test requires further investigation, particularly considering the influence of parental education on children's test results, and also the need for improvements in the alternate form.

2. Clinical Setting Validation:

One of the crucial stages in the process of adapting a neuropsychological test is clinical validation. In this stage, researchers collect data from clinical subjects. The data from this data collection stage is to verify whether the developed test can be used with clients with neuropsychological disorders and whether the resulting scores differ significantly between healthy and impaired respondents. Based on the literature review conducted, it is clear that the Neuropsychological Test Battery for children reviewed in this study has been validated in clinical settings, involving participants (testees) with various neuropsychological and neurodevelopmental disorders, namely: (a) learning disabilities in children at risk of neonatal (Davidson et al., 2006), (b) pediatric multiple sclerosis (Smerbeck et al., 2012), (c) detection of neurodevelopmental disorders that lead to schizophrenia in later developmental stages (Nitzburg et al., 2014), (d) children with congenital heart defects (Wallace et al., advanced publication), and (e) assessment of cognition for abnormal cases and evaluation of treatment effects (Clarck, 2006).

Conclusions

Based on the results of this initial study, it can be concluded that the Neuropsychological Test Batteries developed by previous researchers have proven sensitivity and specificity for use in clinical settings, namely: (a) the Rochester Neuropsychological Test Battery (RTB), which can be used in children exposed to neurotoxicants since birth (neonatal); (b) the MATRICS cognitive consensus battery (MCCB), which can be used to detect neurodevelopmental disorders that result

in schizophrenia; (c) the Neuropsychological Battery for Pediatric Multiple Sclerosis (NBPMS) for pediatric patients with multiple sclerosis; (d) the NIH Toolbox Cognition and Emotions Batteries for children with congenital heart defects; (e) the Brief Neuropsychological Battery for Children (BNBC) for children and adolescents with multiple sclerosis; (f) the Integr-Neuro Cognitive Test, which can be used longitudinally for patients with disorders (or abnormal cognitive function).

In adapting neuropsychological tests, in addition to conducting final testing in a clinical setting to determine the sensitivity and specificity of the neuropsychological test so that it can be used for client/patient testing, a baseline analysis of contextualization is necessary to ensure it can be used culturally appropriately, as well as testing its psychometric properties. Based on the results of this preliminary study, a literature review, two neuropsychological test batteries have been developed in Asia. These studies have reported psychometric properties and cultural adaptation testing, demonstrating the appropriateness of these test batteries for use in context. These are: (a) the Computerized Neurobehavioral Tests in Korean Children for use in Korea; (b) the Neurobehavioral Test Battery for Thai Children for use in Thailand.

Neuropsychological test batteries also contain a variety of tests designed to address various domains of cognitive function. Based on the literature review, it can be concluded that the cognitive function domains uncovered by the test batteries developed by previous researchers include memory, attention, executive function, language, and sensory/psychomotor domains.

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