The Open Psychology Journal
DOI: 10.2174/0118743501406066251024094739, 2025, 18, e18743501406066
ISSN: 1874-3501

REVIEW ARTICLE **OPEN ACCESS**

Executive Functions in Non-WEIRD Populations: Reflections from Ecuador and Thailand

David Villagomez-Pacheco[1], Jennifer Chavanovanich[2,*], María Sol Garcés[3,4] and Graham Pluck[2,4]

[1]*Educational Research Group"NeuroEdUNAE" Universidad Nacional de Educacion-UNAE, Azogues 030105, Ecuador*
[2]*Faculty of Psychology, Chulalongkorn University, Bangkok 10330, Thailand*
[3]*Colegio de Ciencias Sociales y Humanidades, Universidad San Francisco de Quito USFQ, Quito, Ecuador*
[4]*Instituto de Neurociencias, Universidad San Francisco de Quito USFQ, Quito 170901, Ecuador*

Abstract:

Introduction: Executive function, the top-down control of goal-directed behavior, is a critical factor in the development of society. Accordingly, it varies substantially across contexts, with examples of strengths in executive functioning observed in children living in cultures outside of those described as WEIRD (Western, educated, industrialized, rich, and democratic). Scant research has examined the concepts and applications of executive functions in non-WEIRD contexts. To ameliorate this, we aimed to compare two different non-WEIRD cultures.

Methods: Using a reflective-comparative method, we examined aspects of two very different cultures: Ecuador in South America and Thailand in Southeast Asia. As psychologists working in those cultures, we reflected on the difficulties we encountered in assessing executive functions, exploring the challenges and theoretical issues for research and clinical practice.

Results: In both Ecuador and Thailand, the use of executive function as a concept is mainly limited to educational and clinical practice, with little basic psychology research being conducted or published. However, the extent of limiting factors and reasons for limited use vary between the cultures.

Discussion: Our observations emphasized the differences between these cultures, more than the similarities, and how there are no simple solutions to applying WEIRD psychology in non-WEIRD cultures.

Conclusion: Although test adaptation remains an important process, due to the diversity of challenges, we argue that developing bespoke procedures to assess executive functions for experimental or applied work may be an appropriate way forward. Additionally, two-way international collaboration can help refine the concept of executive function in general.

Keywords: Executive functions, Non-WEIRD cultures, Cognitive assessment, Executive function test, Cognition, Neuropsychological perspective.

*Address correspondence to this author at the Faculty of Psychology, Chulalongkorn University, Bangkok 10330, Thailand; E-mail: jennifer.c@chula.ac.th

Cite as: Villagomez-Pacheco D, Chavanovanich J, Garcés M, Pluck G. Executive Functions in Non-WEIRD Populations: Reflections from Ecuador and Thailand. Open Psychol J, 2025; 18: e18743501406066.
http://dx.doi.org/10.2174/0118743501406066251024094739

Received: April 27, 2025
Revised: August 05, 2025
Accepted: August 27, 2025
Published: October 30, 2025

1. INTRODUCTION

The idea of an 'executive controller', a system that governs the lower-level systems, developed originally in computer science in the 1950s, but it has since been widely adopted for understanding cognition in humans and other animals [1]. In fact, it has become perhaps the most widely applied concept from cognitive psychology. Although multiple definitions of executive function exist, key features are that the control is top-down, requiring attention, resource-limited, and goal-directed.

The concept of executive control is the core of the working memory model [2]. However, the most developed cognitive model was provided by Shallice and colleagues, *i.e.*, the supervisory attentional system [3-5]. The supervisory attentional system was later adopted as a model for the previously vaguely defined central executive component of working memory [6].

Regardless of the theoretical perspective, executive functions have become essential in various human sciences, including clinical neuroscience, psychology, linguistics, and pedagogy. This is because they have proven to have predictive value. As an example from neuropsychology, it was found that the modal model of human memory [7] was unable to explain the pattern of memory breakdown in dementia; however, a model that included a central executive [2] was able to adequately explain it [8]. Similarly, executive functions have proven to be useful predictors in diverse applied fields, such as understanding classroom achievement and misbehavior [9], psychopathology [10], and marketing/sales [11]. Accordingly, many cognition and neuroscience researchers now consider executive functions to represent the core of the processes that allow humans to manifest intelligent and highly flexible behavior [12]. Furthermore, there appears to be a fairly consistent set of overlapping cognitive processes that produce the same pattern of strengths and weaknesses across individuals [13].

However, most research on executive functions has been conducted within what are now often referred to as WEIRD cultures, *i.e.*, Western, educated, industrialized, rich, and democratic [14]. Although there is some controversy over the classification, countries commonly identified as WEIRD in the academic literature include Australia, Canada, Germany, Finland, Ireland, the Netherlands, Norway, Spain, Sweden, the UK, and the USA [15].

The limited amount of research in non-WEIRD cultures often reveals results that diverge from those reported from WEIRD cultures. Notably, there appears to be abundant literature on the differential development of executive functions depending on the environment in which children and adolescents are raised, particularly regarding deprivation and socioeconomic status (SES). A few notable examples are better working memory in child laborers in Nepalese carpet factories, compared to school-attending children [16], better divergent thinking in homeless street children, compared to non-homeless children in Bolivia [17], better mathematical skills in child street vendors compared to school-attending children in Brazil [18], and better cognitive flexibility and response inhibition in low-SES South-Africa children compared to much higher SES Australian children [19].

Importantly, these examples cannot be explained by a general advantage of growing up in privileged contexts, as is often observed when middle-class adolescents perform better on executive cognitive tests than working-class adolescents [20, 21]. In the four examples, the children growing up with the least privilege demonstrated better cognition involving executive control. This suggests that cultural differences may have strong, sometimes positive shaping effects on executive function development. They are so strong, in fact, that they can manifest as strengths despite a pervasive negative impact on many other aspects of physical, psychological, economic, and social development. The above-mentioned findings are consistent with recent theorizing that executive functions, rather than following an invariant developmental trajectory, develop within a context of experiences, social norms, knowledge, belief systems, and values [22].

Indeed, with increasing recognition of the importance of sample diversity, cognitive sciences are becoming more aware of the atypicality of the samples they study. The majority of research (and theorizing), for example, has been based on English speakers. However, the English language has lots of idiosyncratic features, in phonology, grammar, morphology, speech habits, *etc.*, and it has been described as a linguistic outlier [23]. Nevertheless, cognitive theories and practices involving language have been thoughtlessly generalized to all linguistic cultures. An overgeneralization with even greater impact, long recognized but only recently receiving attention in the cognitive sciences, is the effect of schooling [24]. As cognitive sciences now have a good understanding of the influences of education on cognitive development, it is becoming clear that research has focused almost entirely on people who have been formally schooled, but such people are not representative of all human beings. Certainly, from a historical perspective, the normal state of the human cognitive system is not schooled.

Given the importance of cultural variables in shaping cognitive abilities, observations from non-WEIRD cultures of executive functions, such as differential development or breakdown associated with neurological disease, would be highly informative. This would not only allow the development of knowledge more broadly applicable to the human species, but would also allow the development of a more complete understanding of cognitive mechanisms. A gap persists between WEIRD and non-WEIRD cultures, with a dearth of studies in the latter.

In this paper, we aimed to explore barriers and issues in the assessment of executive function as a cognitive skill, particularly with respect to cultural variables, in two quite different non-WEIRD cultures: Ecuador in South America and Thailand in Southeast Asia. We considered only executive functions for two reasons. Firstly, treating all cognitive processes would mean that only a small amount of attention could be devoted to executive control. Secondly, and related to that first point, we argue that

executive functions have a central, bi-directional position in the development of human culture. This argument is expanded in the following sections.

1.1. Executive Functions and Human History

Earlier in this text, we have described studies linking child labor, homelessness, and poverty to enhanced executive function, suggesting a strong influence of culture on the development of these functions. Such associations are likely of interest to anthropology and related disciplines that study how culture interacts with human development. Despite this, the contribution of anthropology to understanding cognitive functions has remained relatively limited until recently [25]. However, there is a resurgence of interest in the cultural and social contributions to cognitive phenomena. A recent and influential review focused on neuropsychiatry concluded that nearly all cognition is social in some way, and further, nearly all psychiatric illnesses are based on social cognition [26]. Metacognition was seen as crucial to understanding these concepts within a classical executive function framework (*i.e.*, the supervisory system of Norman and Shallice [3]).

Similarly, paleoanthropology was once focused on language use as the core human skill, allowing advanced cultural development. Language was seen as the factor distinguishing modern humans from their ancestors [27]. However, recently, there has been interest in how the development of cognitive-control skills in archaic humans, specifically executive working memory ability, may have contributed to their survival and to their relatively recent grand achievements, including the development of complex societies, technology, *etc* [28]. This is because executive control allows for technical achievements through insight, planning, and innovation. Hence, it has recently been argued that 'executive functions lay the neural and cognitive foundation for civilization and culture' [29].

The historical origin of executive control in humans is controversial; however, it is clear that some change in cognition has occurred. Some scholars have suggested that a genetic change in the human genome occurred around 100,000 years ago, leading to greater development of the prefrontal cortex [30]. As that area is the part most closely associated with executive function [1, 5, 6, 13], the change may have provided a biological substrate for increased behavioral flexibility. In addition, enhanced working memory, a key aspect of executive function, may have allowed ancient humans to make greater use of complex skills learnt and stored in long-term memory, providing for more flexible technical cognition [28]. An alternative explanation is that the social nature of human existence, spanning from hundreds of thousands of years ago to modern times, has driven the need for a flexible cognitive system that provides reflection, allowing for complex interactive behaviors, such as reciprocal altruism, imitation, self-regulation, social manipulation, and defenses against that manipulation [31]. In the context of the self-regulatory model, the need for social flexibility has led to the evolution of executive cognitive control and the necessary expansion of the prefrontal cortex in humans. This neurocognitive base has allowed for the development of cultural standards, artefacts, tools, and, within recent millennia, writing systems that can sustain advanced cultures [29].

Furthermore, cultural interactions influence executive functions bidirectionally. Evidence from studies on diverse cultures is in support of this. Ethnographic studies with Mayan children in Mexico suggested that the way they apply top-down cognitive control is influenced by their greater autonomy and domestic responsibilities, in contrast to Westernized Mexican children [32]. Evidence from both Slovakia and Vanuatu suggested that following rituals promotes delayed gratification in children, an aspect of inhibitory executive control [33].

1.2. Cross-cultural Influences on Executive Function

From a biological perspective, race does not exist [34]. Therefore, the variation in executive functions observed in different parts of the world is mainly due to cultural variations. A striking example of this comes from brain imaging of cognitive functions. The Go/No-go task measures a core executive function, response inhibition, which is closely linked to activity in the frontal lobes of the brain, as are other core executive functions [13]. When Japanese adults, USA citizens of European descent, and USA citizens of Japanese descent perform this task, their activation within the frontal lobe varies, and the level of activation is associated with their cultural beliefs. Most importantly, activation levels varied between Japanese citizens and the citizens who lived in the USA. But there was no difference in inhibition-induced frontal lobe activation between USA and Japanese Americans [35]. This strongly suggests that the culture people live in is the driving force behind cross-national differences in cognitive processing, and not 'race'.

It has been proposed that executive functions develop from the exertion of reaching goals and meeting the demands within specific living environments through a contextually bound set of knowledge, beliefs, and norms [36]. Thus, given the apparent malleability of executive functions to cultural factors, cross-cultural studies could likely be fruitful methods of identifying the parameters of human executive control. Nevertheless, there is a dearth of studies comparing executive task performance across societies or different sectors of society. Research focused on variation in countries often compares perceived racial groups, a pattern common in USA-based research. For example, historically, it was reported that there exist gaps in cognitive performance of Black and Hispanic populations performing worse than White and Asian students, and gaps between immigrants and non-immigrants, and native and also non-native speakers [37]. Indeed, the background of people and the living context determine how cognitive abilities develop, but 'race' per se is unlikely to be an essential factor.

Returning to studies that correctly focus on culture, one important and replicated observation is that children in some East Asian countries appear to develop executive control at younger ages than children in Western countries. For example, Ellefson *et al.* [38] showed adults

in the U.K. and Hong Kong to perform at equivalent levels on various tests of executive function and develop with age in the same way. However, adolescents in Hong Kong outperformed adolescents in the UK. This suggests that cultural variables affect how quickly executive functions develop from infancy to adolescence, but not the peak of performance in adulthood. Other effects of culture on executive function development in children and adolescents suggest that in most cultures, but not all, girls develop executive function ability faster than boys and that bilingual children develop executive control more readily than monolinguals [39].

Although Ellefson *et al.* [38] found no evidence for adult differences in executive function ability in their East-West comparisons, a study that compared adults raised in the USA and adults raised in India did detect differences in executive task performance across cultures. Kelkar *et al.* [40] found that India-born participants outperformed USA-born participants on some executive function measures, but the reverse pattern was shown on other measures. These East-West comparisons are helpful; however, it should be noted that they make a very broad comparison and also represent only two broad regions. Comparisons between other cultures regarding cognitive function are relatively scarce. One region that is very much left out of these comparisons is Latin America. Although some progress is being made, Gago-Galvagno *et al.* [41] have recently described several idiosyncrasies associated with the development of executive functions in Latin America related to local cultural values, educational systems, income inequality, *etc*.

Following on, income inequality between countries is likely a substantial factor driving cross-cultural gaps in cognitive test performance. Executive functions have been identified as cognitive skills of particular interest in understanding and aiding national socioeconomic development [42]. Nevertheless, there are likely other factors that may cause differences in executive skills between cultures. One might be how tests are designed. It is well-known that most commercially sold cognitive assessments (*e.g.*, intelligence test batteries) are mainly developed for application within WEIRD cultures. The criticism suggests that this is problematic because of the lack of an adequate representation of a diverse population in the development of cognitive tests. Consequently, there may be a major problem with how culture-fair the tests are. We can take as an example the Pyramids and Palm Trees Test, which is widely used to assess semantic knowledge. When this was applied in Thailand, 25 of the 52 line-drawing stimuli (48%) were found to be inappropriate, because they portrayed scenes that, although easily recognizable to people in the UK (where the test was developed), were not easily recognizable by Thai people, such as an image of a lord mayor in ceremonial regalia [43]. Similarly, when a battery of different executive function tests from WEIRD countries was applied to indigenous children in Mexico, only 6 (35%) of the children responded, as expected [32].

Nevertheless, Obradović and Willoughby have argued that, across cultures, the fundamentals of executive function are similar, including aspects, such as their criterion validity, biological bases, and relationships with demographic and family predictors [42]. Furthermore, they have provided a 3-step guide to developing executive function assessments for non-WEIRD cultures, starting with a review by local experts to identify possible problems and solutions, using translators from the community, and finally, performing iterative pilot testing to identify and correct any problems.

One reason the fundamentals of executive functions are likely equivalent across cultures, provided the assessment method is appropriate, is the substantial overlap among the processes involved in task performance. Scores on cognitive assessments of executive function are often highly related to the scores on tests of fluid intelligence [44, 45]. This is important for the current analysis as the set of processes underlying fluid intelligence may be the same cognitive processes employed in performing many tests of executive function. This set of procedures is known within cognitive neuroscience as the multiple-demand system [45]. The fact that a core brain network may underlie variation in executive/fluid intelligence is based on the observation that scores on all cognitive tests positively correlate with each other, a phenomenon known as the positive manifold, forming the basis of the concept of general intelligence [46]. The positive manifold has been demonstrated in many cultures, WEIRD and non-WEIRD, suggesting that the core basis of executive functions may be invariant across human cultures [47]. Most relevant to the current analysis, it has been demonstrated in Ecuador as well [48]. A study from Brazil also highlighted these issues. By applying the principles of cognitive measurement proposed by the British psychologist Charles Spearman in 1904 [46], 120 years later, the Brazilian researchers were able to develop a test that performed as expected, yielding a valid measure of general intelligence and the expected relationships with demographic variables [49].

Although the presence of the positive manifold of cognitive test scores appears to be invariant across human cultures and is even seen in a range of non-human animals [50], the stimulus materials used in cognitive tests, particularly executive function assessments, can be a problem. For example, the Delis-Kaplan Executive Function System [51] was the battery of tests that Kelkar *et al*. [40] used to compare USA- and India-raised adults in their cross-cultural study. However, it is a commercial test specifically developed for the USA market and optimized to be in a format suitable for people in the USA. The India-raised participants were tested in English to allow direct comparison with the English-speaking USA-raised participants. This raises the problem that direct comparisons of task performance may never be genuinely culture-fair because the task formats and methods may be more comprehensible within one culture than the other.

The language issue is important as many tests of executive function use words or other linguistic features as stimuli. As an example, the Hayling Test [9] requires participants to complete sentences with either appropriate or inappropriate words, depending on the condition, such as ‘he posted the letter without a …..’. In English, the

language in which the test was originally developed, it is common for objects to appear at the end of a sentence; however, in other linguistic cultures, atypical grammatical structures may be required, or may not be possible at all, making valid test application difficult. Even if the stimulus materials are non-linguistic, there are inevitably task instructions, and, with executive function tests, often quite complex rules to follow. Thus, language can, in some cases, buffer adaptation, making it straightforward, and, in others, pose a risk to validity. For this reason, where possible, it is recommended to choose tasks that minimize language content [42] when planning to adapt assessments to countries different from where they were originally developed. Some scholars have argued that the linguistic content of cognitive tests tends to favor some ethnic groups over others [37], challenging their validity as measures of ability. On the other hand, at the psychometric level, it has been shown that the basic factor structure of cognitive tests across linguistic cultures is invariant [47], suggesting that cross-cultural application may often be appropriate. However, it should also be noted that linguistic differences may be important. Translating task instructions or stimulus materials from English to Korean, Japanese, or Chinese, for example, can be challenging because of the differences in written forms. In contrast, in countries that use a Latin-script adaptation, adaptation may be more straightforward. Similarly, adaption between languages with similar origins, such as the Romance languages spoken in Italy, Spain, Portugal, *etc*., may be less challenging and allow greater validity. Furthermore, language-free assessments are not necessarily free of bias. Classical work in cognitive anthropology has shown that even pictorial stimuli, such as drawings, can be interpreted very differently by people from different cultures [52].

An example of this, and a laudable attempt to address the WEIRD bias in executive function assessment, was a recent ethnographic study with Mayan youth living in Mexico [32]. The Mayans are indigenous to the Americas and have a culture that substantially differs from the Westernized European-heritage majority population. Gaskins and Alcalá [32] found that several aspects of executive function testing, using tasks developed in WEIRD nations, were alien and unmotivating to the Mayan youth, partially explaining their ostensibly relatively low performance. They suggested several ways in which tasks could be developed to be relevant within the culture and hence be more valid measures of actual top-down executive cognitive control.

The point is that various factors influence how test takers can apply and perform cognitive tasks, which vary by culture, separately from true executive processing capacity differences. In this study, we used a qualitative and reflective approach to consider this in more detail by comparing issues encountered by psychologists working in two quite different non-WEIRD cultures, Ecuador (in South America) and Thailand (in Southeast Asia). The researchers working in these countries contributed their experiences to compare and contrast culture-specific issues in the measurement of executive functions. To achieve this, they provided an analysis of the cultural context of each country, linking it to cognitive and assessment issues. Working together, they suggested actions to ameliorate some of the identified problems.

1.3. Review Strategy

The approach was to explore, via reflection and comparison, executive function measurement in two different countries, and provide an overview of the issues. Thus, a review methodology was employed, involving a non-systematic search for relevant articles. Databases searched included Google Scholar, PubMed and Scopus. The main searches were performed between January and February 2024.

2. EXECUTIVE FUNCTION ASSESSMENT IN ECUADOR

As a relatively small country with a relatively young higher-education system, basic academic research in cognitive psychology in Ecuador is very limited. Some studies have attempted to elucidate the functional advantages conferred by executive control by comparing them with school grades [9], and others have attempted to validate existing measures from WEIRD cultures for research use in Ecuador, such as the Victoria Stroop task [53]. In addition to the aforementioned, some attempts have been made at contextualizing executive function tests for the Ecuadorian context. One is a modified Hayling Test, which includes edited sentences from the original Hayling Test and the Reading Span Test [54]. Another example is an adaptation of the EFECO scale as a self-report format, which includes 67 sentences divided into sections with some questions related to different executive-related behaviors [55]. Even though these have been modified to be used in the Ecuadorian context, there are still multiple obstacles for them to become fair assessment tools for use in a diverse population, as exists in Ecuador.

Nevertheless, an urgent need in Ecuador is of appropriate assessments of executive functioning for use in clinical neuropsychological and educational/neuro-developmental contexts. With respect to this latter point, the focus of Ecuadorian psychology on executive functions in a developmental context parallels WEIRD country priorities; a recent bibliographic analysis revealed that most highly-cited research on executive function is published in developmental and neuropsychological journals [56].

From the neuropsychological perspective, understanding executive functions and other high-level cognitive processes and being able to measure them accurately is a crucial feature of a wide range of clinical disciplines, including neurology, psychiatry, clinical psychology, and endocrinology [57]. This is because so many clinical disorders can impinge on efficient brain functioning, and unfortunately, for various reasons, such disorders are overrepresented in non-WEIRD countries, including Ecuador. For example, seizure disorders are a common cause of executive function impairment [58]. They are also

overrepresented in poorer countries, compared to more prosperous countries, and countries with relatively less developed healthcare services, such as Ecuador, where the consequences of such disorders are more severe [59].

The need for executive function measurement and assessment in education is also highlighted here, as access to education substantially influences literacy and cognitive development in Ecuador. Improving the level of education is an ongoing socio-political objective in Ecuador because it is assumed that better teaching and learning can contribute to the improvement of living conditions of the population. This idea may be supported by the belief that education contributes to holistic human development, including the physical, cognitive, social, emotional, and economic domains. In fact, it is strongly supported by evidence that education has a causative effect on improved cognitive processing [60] and that better cognitive ability, in turn, has widespread positive impacts on quality of life [61].

Of course, improved education systems could be beneficial anywhere in the world. Still, they are urgently required in less-developed, non-WEIRD countries with considerable levels of inequity, such as Ecuador. The educational landscape in Ecuador is marked by disparities that reflect broader socio-economic and geographical divides within the country. Educational quality and infrastructure vary significantly across provinces, with rural areas often facing challenges, such as poorly qualified teachers and a lack of access to basic amenities, such as electricity, drinking water, and sanitation. The sections below outline the overall context and barriers to assessment in this South American country.

2.1. Ecuador, Nation and Culture

Ecuador, situated in the northwestern region of South America and intersected by the equatorial line, is a nation of stark contrasts and profound diversity. Historically, colonization by Spain, beginning in the 16th century, has had a huge impact on the country. This took power from the existing states governed by native Amerindian groups, particularly the Inca empire. Although the country has long had independence and statehood, the impact of European culture is ubiquitous. As in most of Latin America, descendants of the European colonizers wield substantially more political and economic power than people within indigenous populations [62]. Another important aspect of Spanish colonization was the introduction of Catholicism, which remains the dominant religion in Ecuador and has had a broad and profound impact on cultural values within the country [63]. This influence cannot be understated and likely drives many aspects of the personality and political attitudes of the Mestizo ethnic majority [64].

The population of Ecuador is over 16 million people, inhabiting its Andean peaks (‘La Sierra’), Amazonian rainforests (‘El Oriente’), coastal plains (‘La Costa’), and insular wonders of the Galapagos Islands [65], and each area has a distinct climate, economy, topography, culture, and demographic characteristics. There are approximately 13 million self-identifying Mestizo inhabitants, and 1.3 million people identify as indigenous, divided into about 19 ethnic groups. In addition, around eight hundred thousand citizens identify as Afro-Ecuadorian, about 1.3 million identify as Montubios (natives of the coastal region), and over three hundred thousand individuals identify as White or other ethnicities. According to the last national poll, there are more than 200,000 immigrants from different countries. Beyond ethnic diversity, there are 14 indigenous languages spoken across diverse regions [66].

It is well known that the living context largely determines the physical and socio-emotional characteristics of a human being [67]. Of course, this is not different for cognitive development. The prevailing socioeconomic conditions in Ecuador are marked by widespread issues, including unemployment, racism, and discrimination [68], which link to the cultural and historical influences on cognitive and emotional development [69]. In addition, the current challenges in Ecuador include malnutrition and ill health, limited education [70], healthcare access disparities [71], proneness to natural disasters, political instability, corruption, endemic violence, crime, and narco-trafficking. The issue of child labor is generally a consequence of economic conditions that favor work over schooling. The location of Ecuador close to the international illegal drugs trade is also important in this respect because many out-of-school children become employed informally in this illicit industry, both in manufacturing and selling [72]. As Ecuador borders Colombia, the long-running conflict in that country has impacted the mental health of many people, particularly at the border regions.

People experiencing poverty in Ecuador constitute a quarter of the population, being income-based, and one in twelve people live in extreme poverty. In the urban areas, the poverty rate is 18% and that of extreme poverty is 4%, whereas in the rural areas, the poverty percentage is 41%, and that of extreme poverty is 17%. Beyond all these socioeconomic issues, Ecuadorian cultural diversity is marked by family- and community-oriented people living in a country with a vast natural richness and several ecosystems that allow the population access to productive lands, affordable organic food, and beautiful landscapes. On the one hand, this represents a positive aspect of Ecuador's potential, impacting the development trajectories of its inhabitants. On the other hand, it also presents significant challenges in providing equitable education, assessment, and diagnostic practices that accommodate language diversity while addressing the cognitive needs of students from such diverse contexts [73].

2.2. Issues in Assessing Executive Functions in Ecuador

At present, there are multiple challenges to assessing executive function in both academic research and applied settings (*e.g.*, educational and clinical). In many cases, these potentially invalidate the findings or promote injustice. One of the most prominent intelligence tests applied in Ecuador is the Wechsler Intelligence Scale for Children [74], based on a hierarchical structure of cognitive processes where the *g factor* (also known as general

intelligence) is a consequence of the positive manifold of correlations among lower-level processes [46, 48, 50]. Contrary to this, Kovacs and Conway [75] argue that there are domain-general processes that correlate more with domain-specific processes than the domain-specific processes with each other. From this perspective, it would be desirable to avoid using non-specific subtests and instead prioritize cognitive evaluations whose processes are more targeted on cognitive constructs, such as working memory or attentional control.

Although many executive cognitive assessments are employed in Ecuador, their use tends to be limited by linguistic and cultural factors. Linguistic problems arise because participants or patients in cognitive research studies need to be assessed in their usual languages. Assessments widely used in the English-speaking world to measure executive function, such as the Hayling Test and the Cognitive Estimates Test, rely on orally delivered stimulus material. Therefore, translation into a local language is needed. In most cases, this problem can be addressed, as Spanish is the main language in Ecuador, and therefore, some tests can be obtained from studies in larger or more developed Latin American countries or in Spain. They can then be adapted to address cultural differences between the originator country and Ecuador. Indeed, this has been done for both the Hayling Test [9] and the Cognitive Estimates Test [76].

However, a substantial proportion of the Ecuadorian population, including many people from the indigenous American populations, does not understand Spanish well. In that case, very few options exist to measure executive function. The Rowland Universal Dementia Assessment Scale is a clinical tool that includes aspects of executive functioning and has been designed to minimize cultural and linguistic effects. This has the potential for use in some indigenous populations in Ecuador and has been shown to function well with indigenous Quechua speakers in neighboring Peru [77]. This is encouraging as Kichwa, a Quechua variation, is the most widely spoken indigenous language in Ecuador.

Nevertheless, language-based executive function assessment options for Ecuadorians who speak indigenous languages remain extremely limited. In this respect, bilingualism among indigenous populations in Ecuador is another element worth considering in terms of executive function assessment. There is an existing controversy concerning whether bilinguals outperform monolinguals in executive tasks. For example, in a study that included 11,000 adults and another that included 4,500 children, there was no difference in executive tasks between monolinguals and bilinguals [78, 79]. In another study, bilingual participants actually performed worse than monolinguals [80]. On the other hand, a study that included 18,000 children showed that those from bilingual homes outperformed those from monolingual homes [81]. Accordingly, Bialystok and Craik [82] argue that bilingualism has a positive lifespan effect on developmental trajectories, academic success, and delayed symptoms of dementia. The aforementioned results suggest that other factors could influence these outcomes, rather than just a simplistic monolingual *vs*. bilingual dichotomy, as the varied sociolinguistics and cultural elements that revolve around language influence its use. Indeed, research on the cognitive science of language has become more insightful as it takes on a sociolinguistic perspective [83]. From a practical perspective, it may be sufficient for the assessors to apply their expertise in the interpretation of cognitive test scores within the context of multilingual test takers. Though this does require quite high levels of training in clinical or educational cognitive assessment, which many psychologists working in Ecuador lack access to.

Fortunately, many common executive function assessments are language-free, as they use rather abstract stimulus materials. The most obvious example is the Wisconsin Card Sort Test [84]. However, the use of those tests has not been explicitly validated for Ecuadorian culture. Furthermore, most executive function tests, such as the Wisconsin Card Sorting Test, and most standardized cognitive tests in general, have been developed within WEIRD English-speaking cultures. There is an often-implicit assumption within such cultures that monolingualism is the norm, and multilingualism is a rare exception. Tests are thus designed from that perspective. However, the monolingualism observed mainly in WEIRD English-speaking cultures is the exception, with multilingualism being the norm in non-WEIRD cultures [85]. The bilingualism or multilingualism of many within the Indigenous American populations of Ecuador, therefore, may influence their cognitive performance in ways that differ from the cognitive constructs assessed in the original WEIRD version.

A further limiting factor is that modern cognitive assessment is rapidly moving towards more ecologically valid methods. For example, the Hotel Test [86] uses a typical British workplace scenario to study time management, attention shifts, *etc*., which are essential components of executive functioning. But as tests become more realistic, as developed in WEIRD countries, more problems emerge in the application in other non-WEIRD contexts. The Hotel Test was used in a research study in Ecuador [87], where the procedures of working in a hotel were somewhat different, and several aspects of the procedure had to be altered, raising issues of construct validity. As another example, the Jansari assessment of Executive Functions, validated in the UK, uses office role-play and is presented in a virtual reality environment [88]. This assessment has been used in some student research studies in Ecuador [89], again with questions about whether ecological validity can apply across cultures.

With respect to the applied issue, the problem of access to valid executive function assessments is more critical. The stakes are high in clinical and educational work involving cognitive assessment of executive functions. A misdiagnosis of impairment or educational potential difficulties can have substantial real-life implications. Related to this, there is a lack of methods for deciding on performance abnormality. In applied work in WEIRD countries, this is usually achieved by using normative tables to estimate how far an individual client's performance falls from the average. Such normative tables are costly and complex to compile and only remain

valid for perhaps a decade. Due to these practical constraints, few normative tables are available for cognitive tests in Ecuador. One exception, which avoided the costs of full norming, was that adjustments for IQ scores on the WAIS-IV for the Ecuadorian population have been provided that can be applied to the original normative tables developed in Spain [90]. The same data set has been used to additionally assess test validity [48]. This approach can circumvent some of the difficulties with test norming in non-WEIRD countries, such as Ecuador, in certain situations.

However, if full normative tables are to be developed for use in Ecuador, following internationally-recognized guidelines, cross-sector collaboration is essential, likely involving commercial, governmental, and NGO support. The practical aspects of collecting sufficiently diverse data, *i.e.*, normative tables of executive function test batteries, cannot be achieved by small groups of academics working alone. This level of collaboration could, however, support fair assessment standards.

3. EXECUTIVE FUNCTION ASSESSMENT IN THAILAND

Thailand, one of the region's most populous and economically developed countries, has relatively advanced healthcare and clinical research systems. Thus, cognitive assessments have been developed primarily for clinical purposes, often as adaptations or extensions of assessments from the United States and other WEIRD countries. This process has, in fact, driven research on executive functions within the field of clinical neuropsychology. One example is the Color Trails Test, now widely used around the world, which was initially validated in part through studies conducted in Thailand [91]. Its development was due to the need for culturally appropriate assessments in clinical studies of cognitive impairment related to HIV infection in Thailand and other countries. The standard Trail Making Test [92] requires the patient to know the English alphabet, making it rather culture-bound. The Thai-developed version replaces alphabetic characters with colors, allowing it to be used in clinical studies across the globe.

Much of the research on executive functions in Thailand has had similar clinical foci. Other research has similarly had an applied focus; for example, studies have examined the effects of exercise on the executive functions of school children [93]. Progress has also been made in more basic research. However, it still has an applied focus, such as investigating the function of working memory by examining its association with orthographic spelling skills [94].

3.1. Thailand, Nation and Culture

Thailand is a middle-income country located in Southeast Asia. Unlike Ecuador, where colonialism has formed much of the modern culture, Thailand has never been colonized by another country [95]. This fact has substantial relevance to the national self-image, outlook, and structure of Thai society. Although many languages are spoken in the country, Central Thai is the dominant language, and most citizens speak it as either a first or second language. It is written in a script that is specific to the country.

Thai culture is considered a rather hierarchically structured society, with significant differences between rich and poor, making it the country with the highest income inequality in the East Asia and Pacific region. This inequality is reflected in differences in human development and leads to disparities in education and occupational levels. A study by Topothai *et al.* [96] revealed that cognitive development was the least attained domain among the four capability domains. The prevalence of appropriate cognitive development was found to be positively correlated with family wealth, as it was associated with better cognitive outcomes. Also, Thailand is ruled by a democratic government; however, the importance of the royal family within Thai culture and governance is substantial.

In terms of cultural values, similar to Ecuador, Thailand places significant importance on collectivism, prioritizing in-group goals, interdependence, and strong ties with extended family. However, Thailand more likely endorses traditional gender roles and less likely assertiveness and competition compared to Ecuador, which places a greater emphasis on status orientation.

The culture of Thailand, historically, has been greatly influenced by Buddhism, which is the dominant religion in the country. This has had, and continues to be, a significant influence on behavior and outlook, influencing many aspects of the day-to-day psychology of Thai people [97]. The culture is also substantially influenced by ancient Chinese culture, particularly Confucianism. This cultural influence cannot be understated, as Confucianist education concepts are interwoven into the Thai approach to learning and teaching. In Thailand, as in other regional nations, this influences academic study, beliefs in how one achieves, and how people should be held responsible for achievements or failures, anxiety, and self-doubt [98]. A strong cultural influence of Confucianism is present in Thailand and its neighboring countries too, and has likely played a substantial role in the overall regional identity, cooperation, and economic development of Southeast Asian nations [99].

Furthermore, while Thailand is predominantly religiously and ethnically homogenous, Muslims constitute the largest minority group, comprising approximately 6% of the population [100]. Islam dominates in the three southernmost provinces bordering Malaysia (*i.e.*, Narathiwat, Yala, and Pattani). The Muslim majority, primarily ethnic Malays, also includes children of immigrants from South Asia, China, Cambodia, and Indonesia, as well as ethnic Thais. Due to the ongoing conflict in the southernmost region, children in this particular area are at risk of developmental delays and growth failure [101]. Negative impacts on child development are also sexual exploitation and trafficking in the region, which is also associated with the substantial narcotics industry [102].

There are approximately 20 distinct communities, known as 'hill tribes' (*chao khao*), comprising approximately 1 million individuals residing in the mountainous northern

and western regions of the country. Each tribe may have a unique language and customs, typically within about five main linguistic families. These populations commonly engage in subsistence farming or swidden agriculture. More importantly, hill tribe communities remain among the poorest in Thailand, with low schooling rates, exacerbated by inadequate schools and a lack of instruction in their native language.

Currently, shortages in various occupational fields in Thailand are reflected in deficits in cognitive skills, such as mathematical reasoning, writing, and reading comprehension, as well as in social skills, such as service orientation, and technical skills, such as programming and technology design. The most lacking knowledge areas are computers and electronics, clerical knowledge, and customer and personal service. With Thailand facing global trends, such as population aging, globalization, and automation, high-level cognitive and social skills shortages are expected to worsen, similar to trends observed in many countries.

Unlike Ecuador, the typical pattern of high levels of epilepsy in low- and middle-income countries is not observed [103]; however, some other disorders with neuropsychological implications are substantially more prevalent, in particular HIV [104].

3.2. Issues in Assessing Executive Functions in Thailand

The increasing demand for clinical neuropsychological assessments, including executive function assessment, has led to the development of several tools for assessing cognition within the Thai population. However, until recently, there have been very few instruments available. Various approaches to the development and use of cognitive assessment tools are evident. The main approach has been to adopt tools developed in other national contexts, primarily in WEIRD countries. Some of these instruments have been used by simply translating administration instructions and materials and relying on the original normative data for interpretation. Others have been modified to improve linguistic and cultural relevance, sometimes with new normative data being collected [105]. In addition, a small number of indigenous instruments have been developed from the ground up to maximize linguistic and cultural relevance (such as the Color Trails Test). Nevertheless, there remains a continuing need for more extensive and up-to-date normative data, particularly for executive function assessments designed for the population of children and adolescents. At present, the development of such tools is often limited by numerous factors, including the limited local expertise available within the country.

Concerning the coverage of the main domains of cognition, the primary purpose of most tests has been found to detect dementia, most typically Alzheimer's disease or mild cognitive impairment. The emphasis has, therefore, been clinical. The domains of orientation, delayed recall, attention, language, and perceptual motor function are relatively well covered. In contrast, executive functions are generally much less covered. However, recent criticism of the lack of coverage of executive functions in the standard dementia screening tests has led to slightly better coverage in some of the more recently developed tests, such as the Montreal Cognitive Assessment, which has recently been validated for clinical use in Thailand [106]. However, even when tests of executive functions are included in these screening tests, they are often not comprehensive.

Some intensive and established neuropsychological tests are applied in Thailand, such as the Delis-Kaplan Executive Function System [51], which has been used, for example, to detect impairments associated with HIV+ status [107]. Nevertheless, there are no Thai-generated norms for this battery that appropriately account for age, education level, and other Thai-specific issues. Researchers have often simply translated the test instruments from the original language into Thai to adapt test materials for executive function assessment procedures in Thailand. This approach, however, fails to address potential differences in understanding the materials, task rules, and other elements that might be culturally relevant. In these cases, the materials are maintained with the original meaning, with only minimal modifications, such as changing a few words in a word list or pictures. Then, these tests are validated by comparing the test performance between clinical groups and healthy controls. Almost all of the tests used or adapted in Thailand have been developed for people over the age of 50 and primarily focused on detecting dementia. Examples are the Mini-Mental State Examination [108] and the Chula Mental Test [109]. These test instruments, therefore, are not suitable for use in younger groups, such as children, adolescents, and those in early or middle adulthood. A notable concern is the lack of executive function tests that have been adapted or validated for the many ethnic minority groups living in Thailand. As a result, options for valid assessment of executive functions within these groups are very limited. In some cases, tests validated in other countries may offer potential usefulness, such as a dementia screening tool that includes executive function items developed for use in Myanmar [110] may be useful within the diaspora of that country residing in Thailand.

The high prevalence of HIV in Thailand [104] has also driven developments in cognitive testing, due to the striking negative impact of AIDS on executive functioning [107]. This has provided impetus to the development and adaptation of tests of executive function to the Thai context [91], as well as for the development of normative performance tables for clinical neuropsychological use of several executive function assessments [111].

Nevertheless, there remains a need for more normative data for educational and clinical assessments. Only two cognitive screening tests account for age, education, or both when generating standard scores that can be used clinically to determine whether performance is impaired. The first is Addenbrooke's Cognitive Screening Test Thai Version, which generates a standardized score referencing age and education [112]. The second is the Thai Montreal Cognitive Assessment [106], which has two cut points based on the level of education to differentiate healthy people from people with cognitive impairment. In summary, the validity and practical applicability of executive function testing adapted in Thailand can be questioned.

From an educational perspective, although research suggests that teachers value executive function as a personal strength among students [113], and some basic research in Thailand highlights the importance of working memory in achievement [94], research in this applied field in Thailand remains minimal. This is partly due to the dearth of tests specifically developed or validated for basic research on children and adolescents in the country. The idiosyncrasies of Thai culture and its language make adopting tests and experimental materials from other cultures for psychoeducational use fraught with problems. Consequently, the use of executive tools in basic cognitive research and in assessing cognitive impairment among Thai individuals is currently challenging. There are several limitations, including the limited number of executive function tests available in Thailand, the methods of test adaptation being difficult, and normative tables being inconsistent with the Thai cultural context. As a result, providing the knowledge of test adaptation to Thai clinicians and researchers is urgent. Additionally, provision of training in cognitive assessment to a professional level is rare in Thailand, as much of clinical and educational psychology focuses on well-being. Addressing issues related to executive function could benefit from greater recognition of the importance of cognitive testing and its integration into postgraduate training courses.

4. COMPARING AND CONTRASTING THE ISSUES

Thailand and Ecuador share several key characteristics. Both are classified as middle-income countries and are defined as non-WEIRD countries. Other similarities include plurinationality, hierarchical social structures, multiple languages spoken, and widespread poverty (linked to a sizeable rich-poor gap). In many ways, these countries face comparable societal challenges, such as being close to international narcotics manufacture and trade routes, as well as the presence of regional armed conflicts along their borders. Such factors have varied implications for child cognitive development in diverse ways, particularly among children living in poverty. For example, in Ecuador and Latin America in general, homeless and street-connected children are sometimes involved in the illicit cocaine industry, which can exacerbate abuse [72]. Similarly, in Thailand and the East Asia region in general, organized crime involving the illicit heroin trade and the linked problem of prostitution, involving children, poses a serious challenge to their psychological development [102].

On the one hand, these challenges highlight the need to understand executive functions and cognition more broadly. On the other hand, the illicit nature of the problems involved limits the academic, educational, and clinical development of knowledge, as these affected populations are among the most difficult groups to reach. This, thus, hinders the implementation of effective assistance programs.

In this sense, both countries are subject to a phenomenon akin to Tudor Hart's Inverse Care Law [114]. Although originated in the field of medicine, this principle is also applicable to educational and other institutions, highlighting the fact that the need for care varies inversely with opportunities for such care. In Tudor Hart's analysis, this is caused by the commoditization of services, making them available most readily to the wealthy. This could undoubtedly apply to educational and clinical assessments in countries, such as Ecuador and Thailand.

It is also important to note that in both countries, the concept of executive function has been employed almost entirely in clinical and educational contexts, with relatively little research on core aspects of cognitive psychology. One contributing factor may be the accessibility of academic research. Psychology research, in general, is overwhelmingly dominated by studies conducted in WEIRD countries. About 81% of research published in leading psychology journals is affiliated with institutions in the United States or other English-speaking countries [115]. The study of cognition, in particular, has been dominated by English-speaking researchers [23]. This dominance of English may create further barriers for researchers who do not use it as a first language (*e.g.*, Thais or Ecuadorians) to publish their findings or access the latest information. A summary of factors affecting executive function measurement in Thailand and Ecuador is provided in Table **1**.

Table 1. Comparative factors affecting executive function assessment in Ecuador and Thailand.

Aspect	Ecuador	Thailand	Shared Issues
Income level	Middle-income, non-WEIRD	Middle-income, non-WEIRD	Structural inequality, child vulnerability
Language/script	Spanish, Latin script (widely shared)	Thai, unique script without word spacing	Language affects test adaptation and literacy
Religion	Predominantly Catholic	Predominantly Buddhist	Cultural foundations influence cognition and learning
History	Colonized by Spain	Never colonized	Influence of foreign cultures
Executive function use	Mostly clinical/educational	Mostly clinical	Little basic cognitive research
Access barriers	Illiteracy linked to poverty	Even elites may struggle with Thai script	Inverse care law: less access where the need is greatest
Adaptation needs	Dual spoken-written input used for marginalized children	Similar need, but the script adds complexity	Digital tools can enable multilingual/multiscript access

Table 2. Executive function evaluation needs in Ecuador and Thailand.

Need	Ecuador	Thailand
Appropriate assessments	Urgent need for appropriate assessments of executive functioning in clinical neuropsychological and educational/neurodevelopmental contexts.	Need for culturally appropriate assessments in clinical studies of cognitive impairment.
Contextualization	Some attempts at contextualizing executive function tests. Multiple obstacles to fair assessment in a diverse population.	More assessments being available for clinical use, though lacking comprehensive methods and batteries.
Educational focus	Access to education substantially influences literacy and cognitive development in Ecuador.	Poverty issues and child exploitation present challenges to cognitive development.
Clinical focus	Limited availability of clinical assessment tools and normative data.	Executive function being well covered in brief screening tools.
Basic research	Some studies have attempted to elucidate the functional advantages conferred by executive control by comparison to school grades.	Limited basic research on cognitive psychology, though some applied work on executive control.

Nevertheless, it is essential to avoid lumping together countries solely based on broad WEIRD *versus* non-WEIRD classifications. The challenges faced by psychologists, academics, educationalists, and clinicians in conducting research on cognitive issues vary across cultures. For example, Ecuador and Thailand vary greatly in terms of religious and ethnic backgrounds. At a fundamental level, the religious background, predominantly Buddhist in Thailand and predominantly Catholic in Ecuador, contributes significantly to cultural differences between the two countries, as well as attitudes, personality, and probably, cognitive facets.

Another important difference lies in language. In the case of Ecuador, the primary language spoken is Spanish, which is one of the most widespread languages in the world. This can allow researchers to access test materials from over 20 other Spanish-speaking countries. Even the script used in Spanish (and the main indigenous American languages) in Ecuador is readable, using the Latin alphabet, a consequence of the European colonization of the region over the 16th to 19th centuries. In contrast, the Thai language and script are practically unique, making it significantly more challenging to adopt tests and experimental procedures developed in other countries. For example, word and sentence reading research in Spanish uses more or less the same procedures as in English, as the languages are very similar. However, Thai script does not include spaces between lexical units, unlike English and Spanish. This not only means that written word segregation in Thai is necessarily different from that in Spanish, but it also poses challenges in adapting material used for cognitive testing and experiments in Thailand.

Related to this difference in scripts is a problem of reading skill within the population. In Ecuador, illiteracy is relatively common among adults, perhaps around 6% [116] of the adult population, and is closely linked to poverty and low educational level. Similar levels of illiteracy are observed in Thailand [117]. However, in the latter, we have observed that more privileged Thai people are often poor readers of Thai script because of their internationalism and reliance on other languages, particularly English. This phenomenon is not often observed in Ecuador, where the most economically privileged are usually quite able to read Spanish text. This is partly due to the uniqueness of the Thai script in comparison to the very-widely used Latin script used in Spanish. One solution is to provide both spoken and written instructions simultaneously to minimize any issues with script recognition. Several commercial cognitive tests already do this, such as the Wechsler tests [74, 90]; however, we have found it a useful adaptation to make to existing assessments of executive function when reading problems are anticipated, for example, with Ecuadorian street-connected children [118]. Related to this, instructions or stimulus materials could be presented in multiple languages, so that the optimal script or language is used for user comprehension. Although this approach would have been challenging in the past, with the current trend toward computerized and online assessment across cultures, and toward big data, multilingual and multiscript implementations may become more accessible.

Overall, our experiences of comparing issues in executive function assessment between Ecuador and Thailand have revealed some commonalities, but more often, differences. This suggests that solutions to idiosyncratic and localized problems are often the priority. A summary of the assessment needs and how they contrast between Ecuador and Thailand is provided in Table **2**.

5. SOLUTIONS FOR ASSESSING EXECUTIVE FUNCTIONS IN NON-WEIRD COUNTRIES

Given cross-cultural differences between countries, even when both are labeled non-WEIRD, alternatives to improve executive function research and assessment require bespoke solutions. Nevertheless, some lessons can be learnt from cross-cultural comparison. One is that language-free tasks may be the easiest to adapt to different cultures. However, it is important to recognize that even language-free tests can have cultural aspects that make them more challenging to complete in some cultures compared to others. Visuospatial tasks developed in Australia to be language-free and cross-cultural appropriate have been, nevertheless, found to be performed differently by elderly indigenous Americans in Peru, for example [77]. Supposedly, language-free executive-function tests developed for use in children in the USA have been found to be interpreted differently by indigenous American children in Mexico [32].

When there is an intention to compare cognitive performance across cultures, it may, therefore, be best to carefully adapt tests to local conditions and evaluate their suitability in the target cultures through pilot studies prior to full-scale data collection. Obradović and Willoughby [42] provided detailed steps on how this adaptation can be performed to measure executive functions in non-WEIRD cultures. For tests intended for use within a specific culture, it may be best to also consider the development of new, culturally appropriate manifestations of tests and experimental procedures while still drawing on the global pool of knowledge from cognitive psychology. An example of how this has been achieved previously is the use of the Trail Making Test in Thailand. This classic assessment of executive function involves joining numbers and letters with a pencil on a page [92]. Participants have to switch between numbers and letters with each line. A Thai version has previously been developed [119], which uses Thai characters instead of the original English alphabet characters; however, as described above, some Thai people are not completely comfortable with the Thai script. Maj *et al*. [91] maintained the overall structure, but replaced the letter characters with colors, either pink or yellow. This allowed the test to better function within Thailand, and also allowed cross-cultural use. The use of colors removed a problem caused by using language-based stimuli.

However, often the cognitive processes that researchers wish to study are fundamentally linguistic. In fact, the cross-cultural differences in language structure often provide natural experiments in understanding human language from a cognitive perspective. Furthermore, language is an important variable that interacts substantially with ostensibly non-linguistic cognitive processes, particularly executive control. For example, inter-individual variation in vocabulary is highly predictive of variation in many executive function tasks, which is a connection that is scientifically very interesting and has practical applications [76].

When language is used in cognitive assessments, it is worth following the advice above on customized testing rather than attempting to adapt through translation. A good example of this is an analysis of lexical reading routes. Many cognitive models propose parallel routes to written word reading, with separate lexical and sublexical routes [120]. A common clinical cognitive assessment, the National Adult Reading Test [121], can be used to assess the lexical route in English by requiring the pronunciation of words with irregular pronunciations. However, words structured that way do not exist in several other languages. Some languages, such as Spanish and Italian, have regular pronunciation, and many languages, such as Chinese and Japanese Kanji, do not use scripts that map symbols to sounds. The functional equivalence can, nevertheless, be achieved, as in Spanish, this is done with the manipulation of written word accent marks [122], and in Japanese, it is done with the pronunciation of compound kanji [123].

These and numerous other word pronunciation tasks in diverse languages have been produced to assess the same cognitive skill, *i.e*., reading words through a lexical route. This can serve as a model of good practice in applying executive function procedures to experimental and applied research in non-WEIRD cultures. Specifically, it is likely a sensible approach to identify the cognitive processes the researcher wishes to study and produce culturally appropriate procedures for eliciting and measuring those processes. A framework for such endeavors is briefly provided below.

5.1. A Framework for Bespoke Executive Function Assessment Development

We suggest several steps that could be used to develop culturally-appropriate assessments of executive function. People familiar with both the concept of executive cognition and the local culture must be involved at every step. This refers to psychologists, neuroscientists, or other relevant experts who are of the same culture or have at least performed relevant ethnographic studies. The first step should be to identify basic aspects of possible tasks that would be compatible with the experiences, existing skills, and interests of the target population. Points to consider here are the medium (*e.g*., spoken, pencil and paper, computerized, or gamified approaches), use of feedback and tolerance of stress, and relatability of the task contents. Secondly, the researchers should research, in detail, the fundamental aspects of executive functioning, such as goal-directedness, attention-demanding, top-down control, limited resources, non-routineness, *etc* [1, 3-6]. The researchers should be focused at this point on what executive control is, in terms of definition, rather than on schemes, classifications, taxonomies of different executive functions, *etc*., as these may be overly biased by WEIRD interpretations and psychometric observations. In the third stage, the researcher must produce a basic task that requires executive control and harmonizes with the previous stages. This is the stage that requires innovation. However, novel cognitive test design is already commonplace in fields, such as experimental psychology, and also clinical [124] and cognitive [125] neuropsychology, and the same principles can be applied here. Important practical considerations include producing an assessment that yields a range of scores without ceiling or floor effects, with the range determined by the efficiency of executive control. An additional consideration at this stage is test reliability. These steps, if followed closely, may produce a culturally-appropriate assessment with face validity as a measure of executive function. The next stage requires piloting on diverse participants, but including those from the target population. A final, optional stage could be to assess more formally the validity of the assessment, for example, demonstrating that achievement measures on the task are negatively associated with psychiatric or neurological illness.

CONCLUSION

Executive function, a broad concept describing top-down cognitive control of processes to produce goal-directed behavior, is a core issue in cognitive psychology. It is increasingly being recognized that the social and cultural context that people develop within has an important role in sculpting executive control mechanisms [26, 29]. Despite

this, culturally oriented cognitive research, which could help further define human executive control parameters, is scarce. This is partly due to the dominance of cognitive psychology research by a handful of WEIRD countries. The significance of the current study is that we have brought attention to several of the problems of applying cognitive psychology in non-WEIRD cultures, and furthermore, we have provided suggestions and a formal framework for how some of these problems can be addressed. This may prove a useful starting point for others working outside of the traditional cultures that dominate modern psychology and cognitive science.

The approach used in this paper involves comparing our personal experiences; thus, our method can be described as qualitative and reflective–comparative, drawing on our professional experiences working in Ecuador and Thailand. We are all academics and clinicians working in those cultures and regularly face issues envisaging executive control in these contexts. In both cultures, there has been an emphasis on the clinical and educational application of the concept of executive control, with much more limited conceptual work. This is perhaps due to the lack of foundations in academic work on cognition in these countries. In this sense, many issues are the same between Thailand and Ecuador. There is, therefore, some advantage in exploring the commonality of issues and solutions. Nevertheless, the cultures are very different, and those differences provide practical constraints on how cognitive psychology can operate in different locations.

From our experiences, we have learnt that it is better not to focus on the needs and achievements of non-WEIRD countries (as a class), but on the idiosyncrasies of the individual cultures. Although the WEIRD concept has some heuristic use, in practice, appreciation of diversity and specific challenges can become blurred when applying the dichotomy. Equally, the same could be argued about the countries considered WEIRD. By focusing on individual characteristics and issues within cultures, specific improvements can be more easily achieved, for example, refining the use of cognitive assessments and concepts, such as executive function, as focused on in the present study. In addition, these applications and studies can help redefine the overall, globally used concept of executive function, which is currently overly influenced by observations from a WEIRD perspective. Greater international collaboration and appreciation of findings originating in non-WEIRD cultures are needed. However, knowledge exchange must be two-way to achieve these goals, *i.e.*, WEIRD executive function research must be open to improvement and extension from those working in non-WEIRD cultures. We have thus suggested ways in which cognitive psychology can be explored and applied across different contexts and provided a framework for test development that applies core concepts in culturally appropriate ways.

AUTHORS' CONTRIBUTIONS

The authors confirm their contribution to the paper as follows: D.V.P.: Original draft preparation; J.C.: Writing, review, and editing; M.S.G., G.P.: Writing of the paper. All authors approved the final version of the manuscript.

LIST OF ABBREVIATIONS

G FACTOR	=	General Intelligence
SES	=	Socioeconomic Status
WEIRD	=	Western, Educated, Industrialized, Rich, and Democratic

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

This study was supported by a Research Grant, Endowment Fund Contract, Research Affairs, Faculty of Psychology, Chulalongkorn University, Thailand (PSY-CU-05-2564).

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The authors would like to thank Rabia Jan for assistance in the formatting of the manuscript.

REFERENCES

[1] Pluck G, Cerone A, Villagomez-Pacheco D. 2023. http://dx.doi.org/10.1007/978-3-031-26236-4_27
[2] Baddeley AD, Hitch GJ. Working memory. 1974. http://dx.doi.org/10.1016/S0079-7421(08)60452-1
[3] Norman DA, Shallice T. 1986. http://dx.doi.org/10.1007/978-1-4757-0629-1_1
[4] Shallice T, Burgess P. The domain of supervisory processes and temporal organization of behaviour. Philos Trans R Soc Lond B Biol Sci 1996; 351(1346): 1405-12. http://dx.doi.org/10.1098/rstb.1996.0124 PMID: 8941952
[5] Shallice T, Cipolotti L. The prefrontal cortex and neurological impairments of active thought. Annu Rev Psychol 2018; 69(1): 157-80. http://dx.doi.org/10.1146/annurev-psych-010416-044123 PMID: 28813204
[6] Baddeley A, Della Sala S. Working memory and executive control. Philos Trans R Soc Lond B Biol Sci 1996; 351(1346): 1397-404. http://dx.doi.org/10.1098/rstb.1996.0123 PMID: 8941951
[7] Atkinson R, Shiffrin R. Human memory: A proposed system and its control processes. 1968. http://dx.doi.org/10.1016/S0079-7421(08)60422-3
[8] Spinnler H, Sala SD, Bandera R, Baddeley A. Dementia, ageing, and the structure of human memory. Cogn Neuropsychol 1988; 5(2): 193-211. http://dx.doi.org/10.1080/02643298808252933
[9] Pluck G, Villagomez-Pacheco D, Karolys MI, Montaño-Córdova ME, Almeida-Meza P. Response suppression, strategy application, and working memory in the prediction of academic performance and classroom misbehavior: A neuropsychological approach. Trends Neurosci Educ 2019; 17100121 http://dx.doi.org/10.1016/j.tine.2019.100121 PMID: 31685128
[10] Snyder HR, Miyake A, Hankin BL. Advancing understanding of executive function impairments and psychopathology: bridging the gap between clinical and cognitive approaches. Front Psychol 2015; 6: 328. http://dx.doi.org/10.3389/fpsyg.2015.00328 PMID: 25859234
[11] Pluck G, Crespo-Andrade C, Parreño P, Haro KI, Martínez MA, Pontón SC. Executive functions and intelligent goal-directed behavior: A neuropsychological approach to understanding success using professional sales as a real-life measure. Psychol

Neurosci 2020; 13(2): 158-75.
http://dx.doi.org/10.1037/pne0000195
[12] Cristofori I, Cohen-Zimerman S, Grafman J. Executive functions. Handb Clin Neurol 2019; 163: 197-219.
http://dx.doi.org/10.1016/B978-0-12-804281-6.00011-2 PMID: 31590731
[13] Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: a latent variable analysis. Cognit Psychol 2000; 41(1): 49-100.
http://dx.doi.org/10.1006/cogp.1999.0734 PMID: 10945922
[14] Henrich J, Heine SJ, Norenzayan A. The weirdest people in the world? Behav Brain Sci 2010; 33(2-3): 61-83.
http://dx.doi.org/10.1017/S0140525X0999152X PMID: 20550733
[15] Beyebach M, Neipp MC, Solanes-Puchol Á, Martín-del-Río B. Bibliometric differences between WEIRD and non-WEIRD countries in the outcome research on solution-focused brief therapy. Front Psychol 2021; 12754885
http://dx.doi.org/10.3389/fpsyg.2021.754885 PMID: 34867649
[16] Alaraudanjoki E, Regmi MP, Ahonen T, Nurmi JE, Ruoppila I. Cognitive skills among Nepalese child labourers. Int J Psychol 2001; 36(4): 242-50.
http://dx.doi.org/10.1080/00207590042000164
[17] Dahlman S, Bäckström P, Bohlin G, Frans Ö. Cognitive abilities of street children: Low-SES Bolivian boys with and without experience of living in the street. Child Neuropsychol 2013; 19(5): 540-56.
http://dx.doi.org/10.1080/09297049.2012.731499 PMID: 23043625
[18] Saxe GB. The mathematics of child street vendors. Child Dev 1988; 59(5): 1415-25.
http://dx.doi.org/10.2307/1130503
[19] Howard SJ, Cook CJ, Everts L, *et al*. Challenging socioeconomic status: A cross-cultural comparison of early executive function. Dev Sci 2020; 23(1)e12854
http://dx.doi.org/10.1111/desc.12854 PMID: 31077525
[20] Pluck G, Córdova MA, Bock C, Chalen I, Trueba AF. Socio-economic status, executive functions, and theory of mind ability in adolescents: Relationships with language ability and cortisol. Br J Dev Psychol 2021; 39(1): 19-38.
http://dx.doi.org/10.1111/bjdp.12354 PMID: 33052603
[21] Pluck G. ABO blood group, socioeconomic status, and cognitive function: Evidence from college students for better visual recognition associated with the Type O phenotype. J Cogn Sci 2022; 23(4): 493-524.
http://dx.doi.org/10.17791/jcs.2022.23.4.493
[22] Doebel S. Rethinking executive function and its development. Perspect Psychol Sci 2020; 15(4): 942-56.
http://dx.doi.org/10.1177/1745691620904771 PMID: 32348707
[23] Blasi DE, Henrich J, Adamou E, Kemmerer D, Majid A. Over-reliance on English hinders cognitive science. Trends Cogn Sci 2022; 26(12): 1153-70.
http://dx.doi.org/10.1016/j.tics.2022.09.015 PMID: 36253221
[24] Kroupin I, Davis HE, Zeng TC, Henrich J. Back to school: How formal education has shaped almost all of cognitive science. 2024.
http://dx.doi.org/10.31234/osf.io/tqy2n
[25] Beller S, Bender A, Medin DL. Should anthropology be part of cognitive science? Top Cogn Sci 2012; 4(3): 342-53.
http://dx.doi.org/10.1111/j.1756-8765.2012.01196.x PMID: 22685087
[26] Frith U, Frith C. What makes us social and what does it tell us about mental disorders? Cogn Neuropsychiatry 2024; 29(1): 1-9.
http://dx.doi.org/10.1080/13546805.2024.2307958 PMID: 38281115
[27] Schepartz LA. Language and modern human origins. Am J Phys Anthropol 1993; 36(S17): 91-126.
http://dx.doi.org/10.1002/ajpa.1330360607
[28] Wynn T, Coolidge FL. The expert performance model of Neandertal cognition.Learning among Neanderthals and Palaeolithic modern humans. Singapore: Springer 2019; pp. 23-34.
http://dx.doi.org/10.1007/978-981-13-8980-1_3
[29] Sarma UA, Mariam Thomas T. Breaking the limits of executive functions: Towards a sociocultural perspective. Cult Psychol 2020; 26(3): 358-68.
http://dx.doi.org/10.1177/1354067X19898673
[30] Coolidge FL, Wynn T. Working memory, its executive functions, and the emergence of modern thinking. Camb Archaeol J 2005; 15(1): 5-26.
http://dx.doi.org/10.1017/S0959774305000016
[31] Barkley RA. The executive functions and self-regulation: an evolutionary neuropsychological perspective. Neuropsychol Rev 2001; 11(1): 1-29.
http://dx.doi.org/10.1023/A:1009085417776 PMID: 11392560
[32] Gaskins S, Alcalá L. Studying executive function in culturally meaningful ways. J Cogn Dev 2023; 24(2): 260-79.
http://dx.doi.org/10.1080/15248372.2022.2160722
[33] Rybanska V, McKay R, Jong J, Whitehouse H. Rituals improve children's ability to delay gratification. Child Dev 2018; 89(2): 349-59.
http://dx.doi.org/10.1111/cdev.12762 PMID: 28213887
[34] AAPA statement on biological aspects of race. Am J Phys Anthropol 1996; 101(4): 569-70.
http://dx.doi.org/10.1002/ajpa.1331010408
[35] Pornpattananangkul N, Hariri AR, Harada T, *et al*. Cultural influences on neural basis of inhibitory control. Neuroimage 2016; 139: 114-26.
http://dx.doi.org/10.1016/j.neuroimage.2016.05.061 PMID: 27263507
[36] Miller-Cotto D, Smith LV, Wang AH, Ribner AD. Changing the conversation: A culturally responsive perspective on executive functions, minoritized children and their families. Infant Child Dev 2022; 31(1)e2286
http://dx.doi.org/10.1002/icd.2286
[37] Holden LR, Tanenbaum GJ. Modern assessments of intelligence must be fair and equitable. J Intell 2023; 11(6): 126.
http://dx.doi.org/10.3390/jintelligence11060126 PMID: 37367528
[38] Ellefson MR, Ng FFY, Wang Q, Hughes C. Efficiency of executive function: A two-generation cross-cultural comparison of samples from Hong Kong and the United Kingdom. Psychol Sci 2017; 28(5): 555-66.
http://dx.doi.org/10.1177/0956797616687812 PMID: 28384072
[39] Schirmbeck K, Rao N, Maehler C. Similarities and differences across countries in the development of executive functions in children: A systematic review. Infant Child Dev 2020; 29(1)e2164
http://dx.doi.org/10.1002/icd.2164
[40] Kelkar AS, Hough MS, Fang X. Do we think alike? A cross-cultural study of executive functioning. Cult Brain 2013; 1(2-4): 118-37.
http://dx.doi.org/10.1007/s40167-013-0010-4
[41] Gago-Galvagno LG, Miller SE, Mancini NA, Simaes AC, Elgier AM, Azzollini SC. Importance of cultural context in the study of children's executive functions: Advances in Latin America research. Child Dev Perspect 2024; 18(3): 115-22.
http://dx.doi.org/10.1111/cdep.12505
[42] Obradović J, Willoughby MT. Studying executive function skills in young children in low-and middle-income countries: Progress and directions. Child Dev Perspect 2019; 13(4): 227-34.
http://dx.doi.org/10.1111/cdep.12349
[43] Singwicha D, Rattanabannakit C, Hunnangkul S, *et al*. Validation of the adapted picture version of the pyramids and palm trees test for thais with dementia. Siriraj Medical Journal 2024; 76(12): 840-5.
http://dx.doi.org/10.33192/smj.v76i12.270244
[44] Roca M, Manes F. Bridging experimental neuroscience and clinical neuropsychology: Fluid intelligence in frontal lobe assessments. Neuropsychologia 2024; 205109016
http://dx.doi.org/10.1016/j.neuropsychologia.2024.109016 PMID: 39427752
[45] Duncan J. The multiple-demand (MD) system of the primate brain: mental programs for intelligent behaviour. Trends Cogn Sci 2010;

14(4): 172-9.
http://dx.doi.org/10.1016/j.tics.2010.01.004 PMID: 20171926
[46] Spearman C. “General intelligence,” objectively determined and measured. Am J Psychol 1904; 15(2): 201-92.
http://dx.doi.org/10.2307/1412107
[47] Wilson CJ, Bowden SC, Byrne LK, Joshua NR, Marx W, Weiss LG. The cross-cultural generalizability of cognitive ability measures: A systematic literature review. Intelligence 2023; 98101751
http://dx.doi.org/10.1016/j.intell.2023.101751
[48] Pluck G, Cerone A. 2021.https://escholarship.org/uc/item/2b90z3jx
[49] Anunciação L, Marques L, Murray C, *et al*. Psychometric properties of a brief non-verbal test of g factor intelligence. Journal of Psychological Perspective 2024; 6(1): 47-62.
http://dx.doi.org/10.47679/jopp.617532024
[50] Burkart JM, Schubiger MN, van Schaik CP. The evolution of general intelligence. Behav Brain Sci 2017; 40e195
http://dx.doi.org/10.1017/S0140525X16000959 PMID: 27464851
[51] Delis DC, Kaplan E, Kramer JH. Delis-Kaplan Executive Function System Technical Manual. San Antonio, TX: The Psychological Corporation 2001.
http://dx.doi.org/10.1037/t15082-000
[52] Deregowski JB. Pictorial perception and culture. Sci Am 1972; 227(5): 82-8.
http://dx.doi.org/10.1038/scientificamerican1172-82 PMID: 4576038
[53] Ramos C. Adaptación del test stroop victoria en estudiantes ecuatorianos. Rev Iberoam Diagn Eval Psicol 2017; 44(2): 57-64.
http://dx.doi.org/10.21865/RIDEP44.2.05
[54] Villagómez D, Pluck G, Almeida P. Relación entre la memoria de trabajo, inhibición de respuesta, y habilidad verbal con el éxito académico y el comportamiento en adolescentes 2017.https://publicaciones.ucuenca.edu.ec/ojs/index.php/maskana/article/view/1879
[55] Ramos-Galarza C, Jadán-Guerrero J, García-Gómez A, Paredes L. Propuesta de la escala efeco para evaluar las funciones ejecutivas en formato de auto-reporte. CienciAmérica 2016; 5(1): 104-9.
[56] Heidary S, Hashemi Z, Jamali SM, Ebrahim NA. Quantitative and qualitative analysis of executive functions: a bibliometric approach. Curr Psychol 2024; 43(11): 10029-47.
http://dx.doi.org/10.1007/s12144-023-05033-x
[57] Pluck G, Ariyabuddhiphongs K. Clinical cognitive sciences. 2024.
http://dx.doi.org/10.1007/978-3-031-66021-4_9
[58] Black LC, Schefft BK, Howe SR, Szaflarski JP, Yeh H, Privitera MD. The effect of seizures on working memory and executive functioning performance. Epilepsy Behav 2010; 17(3): 412-9.
http://dx.doi.org/10.1016/j.yebeh.2010.01.006 PMID: 20153981
[59] Rivero Rodríguez D, Scherle Matamoros C, Dicapua Sacoto D, Garcia-Ptacek S, Pernas Sanchez Y, Pluck G. Predisposing factors and impact of healthcare-associated infections in patients with status epilepticus. Arq Neuropsiquiatr 2021; 79(3): 209-15.
http://dx.doi.org/10.1590/0004-282x-anp-2019-0365 PMID: 33886794
[60] Ritchie SJ, Tucker-Drob EM. How much does education improve intelligence? A meta-analysis. Psychol Sci 2018; 29(8): 1358-69.
http://dx.doi.org/10.1177/0956797618774253 PMID: 29911926
[61] Brown MI, Wai J, Chabris CF. Can you ever be too smart for your own good? Comparing linear and nonlinear effects of cognitive ability on life outcomes. Perspect Psychol Sci 2021; 16(6): 1337-59.
http://dx.doi.org/10.1177/1745691620964122 PMID: 33682520
[62] Hall GH, Patrinos HA. Introduction.Indigenous peoples, poverty, and development. New York: Cambridge University Press 2012.
http://dx.doi.org/10.1017/CBO9781139105729.001
[63] DeTemple J, Tomalin E. Inca roads, protestant hospitals, catholic cheese, and the fluctuating state: Religion and development in Ecuador.The Routledge handbook of religions and global development. London: Routledge 2015; pp. 156-66.
http://dx.doi.org/10.4324/9780203694442
[64] Armendariz Miranda P, Cawvey M. Introverted and closed-minded: The psychological roots of support for autocracy in Latin America. J Polit Lat Am 2021; 13(1): 40-66.
http://dx.doi.org/10.1177/1866802X21991261
[65] Jolly PM, Van Hoof H, Chen F, *et al*. Quantifying cultural tightness-looseness in Ecuador. PLoS One 2021; 16(1)e0246064
http://dx.doi.org/10.1371/journal.pone.0246064 PMID: 33513147
[66] Vernimmen Aguirre G. Ecuadorian intercultural education: A conceptual review. Alteridad 2019; 14(2): 162-71.
http://dx.doi.org/10.17163/alt.v14n2.2019.01
[67] Papalia DE, Feldman RD, Martorell G. Experience human development. New York: McGraw-Hill 2012.
[68] Oviedo Oviedo A. 2022.
http://dx.doi.org/10.17141/mundosplurales.2.2022.5483
[69] Pagani C. Violence in cross-cultural relations as the outcome of specific cognitive and emotional processes. Open Psychol J 2011; 4(1): 21-7.
http://dx.doi.org/10.2174/1874350101104010021
[70] Rindermann H, Carl N. Indigenous Ecuadorian children: Parental education, parental wealth and children’s cognitive ability level. Learn Individ Differ 2017; 54: 202-9.
http://dx.doi.org/10.1016/j.lindif.2017.01.025
[71] Quizhpe E, Teran E, Pulkki-Brännström AM, San Sebastián M. Social inequalities in healthcare utilization during Ecuadorian healthcare reform (2007–2017): a before-and-after cross-sectional study. BMC Public Health 2022; 22(1): 499.
http://dx.doi.org/10.1186/s12889-022-12884-9 PMID: 35287629
[72] Pluck G. Street children in Latin America.Homelessness and mental health. Oxford, UK: Oxford University Press 2022; pp. 59-70.
http://dx.doi.org/10.1093/med/9780198842668.003.0005
[73] Guijarro-Garví M, Miranda-Escolar B, Cedeño-Menéndez YT, Moyano-Pesquera PB. Education as a dimension of human development: A Provincial-level Education Index for Ecuador. PLoS One 2022; 17(7)e0270932
http://dx.doi.org/10.1371/journal.pone.0270932 PMID: 35802576
[74] Wechsler D. Wechsler Intelligence Scale for children. Madrid 2004.
[75] Kovacs K, Conway ARA. Process overlap theory: A unified account of the general factor of intelligence. Psychol Inq 2016; 27(3): 151-77.
http://dx.doi.org/10.1080/1047840X.2016.1153946
[76] Pluck G, Ruales-Chieruzzi CB. Estimation of premorbid intelligence and executive cognitive functions with lexical reading tasks. Psychol Neurosci 2021; 14(3): 358-77.
http://dx.doi.org/10.1037/pne0000264
[77] Zegarra-Valdivia JA, Quispe RDM, Turpo JC, *et al*. Evaluation of cognitive profile through Q-RUDAS: first approach in Quechua Participants. Alzheimers Dement 2023; 19(S24)e083225
http://dx.doi.org/10.1002/alz.083225
[78] Nichols ES, Wild CJ, Stojanoski B, Battista ME, Owen AM. Bilingualism affords no general cognitive advantages: A population study of executive function in 11,000 people. Psychol Sci 2020; 31(5): 548-67.
http://dx.doi.org/10.1177/0956797620903113 PMID: 32310712
[79] Dick AS, Garcia NL, Pruden SM, *et al*. No evidence for a bilingual executive function advantage in the ABCD study. Nat Hum Behav 2019; 3(7): 692-701.
http://dx.doi.org/10.1038/s41562-019-0609-3 PMID: 31110341
[80] Okada K, He G, Gonzales A. Monolinguals and bilinguals differ in performance on the Taboo Stroop task. Open Psychol J 2019; 12(1): 135-40.
http://dx.doi.org/10.2174/1874350101912010135
[81] Hartanto A, Toh WX, Yang H. Bilingualism narrows socioeconomic disparities in executive functions and self-regulatory behaviors during early childhood: Evidence from the early childhood longitudinal study. Child Dev 2019; 90(4): 1215-35.
http://dx.doi.org/10.1111/cdev.13032 PMID: 29318589
[82] Bialystok E, Craik FIM. How does bilingualism modify cognitive function? Attention to the mechanism. Psychon Bull Rev 2022; 29(4): 1246-69.
http://dx.doi.org/10.3758/s13423-022-02057-5 PMID: 35091993

[83] Bak T. Why cognitive neuroscience leads us to sociolinguistics 2020.https://www.research.ed.ac.uk/en/publications/why-cognitive-neuroscience-leads-us-to-sociolinguistics/
[84] Nelson HE. A modified card sorting test sensitive to frontal lobe defects. Cortex 1976; 12(4): 313-24. http://dx.doi.org/10.1016/S0010-9452(76)80035-4 PMID: 1009768
[85] Bak TH, Alladi S. Can being bilingual affect the onset of dementia? Future Neurol 2014; 9(2): 101-3. http://dx.doi.org/10.2217/fnl.14.8
[86] Manly T, Hawkins K, Evans J, Woldt K, Robertson IH. Rehabilitation of executive function: facilitation of effective goal management on complex tasks using periodic auditory alerts. Neuropsychologia 2002; 40(3): 271-81. http://dx.doi.org/10.1016/S0028-3932(01)00094-X PMID: 11684160
[87] Pluck G, Ruales-Chieruzzi CB, Paucar-Guerra EJ, Andrade-Guimaraes MV, Trueba AF. Separate contributions of general intelligence and right prefrontal neurocognitive functions to academic achievement at university level. Trends Neurosci Educ 2016; 5(4): 178-85. http://dx.doi.org/10.1016/j.tine.2016.07.002
[88] Jansari AS, Devlin A, Agnew R, Akesson K, Murphy L, Leadbetter T. Ecological assessment of executive functions: A new virtual reality paradigm. Brain Impair 2014; 15(2): 71-87. http://dx.doi.org/10.1017/BrImp.2014.14
[89] García Centeno DE. Evaluación transcultural de las funciones ejecutivas de estudiantes universitarios ecuatorianos, ingleses y tailandeses utilizando una nueva prueba de realidad virtual llamada Jansari Assessment of Executive Functions Doctor of Philosophy. Universidad San Francisco de Quito 2023.
[90] Pluck G, Mayorga-Albán A, Hernandez-Rodriguez JL, Garcés MS, Bravo-Mancero P. Uso de la Escala de Inteligencia de Adultos de Wechsler-IV para la evaluación neuropsicológicas en Ecuador. Revista Ecuatoriana de Neurologia 2022; 30(3): 38-45. http://dx.doi.org/10.46997/revecuatneurol30300038
[91] Maj M, D'Elia L, Satz P, *et al.* Evaluation of two new neuropsychological tests designed to minimize cultural bias in the assessment of HIV-1 seropositive persons: A WHO study. Arch Clin Neuropsychol 1993; 8(2): 123-35. http://dx.doi.org/10.1093/arclin/8.2.123 PMID: 14589670
[92] Reitan RM. The relation of the Trail Making Test to organic brain damage. J Consult Psychol 1955; 19(5): 393-4. http://dx.doi.org/10.1037/h0044509 PMID: 13263471
[93] Sriramatr S, Maphong R. The acute effects of actively play on the executive functions of Thai children. Physical Activity Review 2022; 10(1): 1-9. http://dx.doi.org/10.16926/par.2022.10.01
[94] Wixey AJ, Eamoraphan S. 2017.
[95] Streckfuss D. An 'ethnic' reading of 'Thai' history in the twilight of the century-old official 'Thai' national model. South East Asia Res 2012; 20(3): 305-27. http://dx.doi.org/10.5367/sear.2012.0115
[96] Topothai T, Suphanchaimat R, Topothai C, Tangcharoensathien V, Cetthakrikul N, Waleewong O. Thailand achievement of SDG indicator 4.2.1 on early child development: An analysis of the 2019 multiple indicator cluster survey. Int J Environ Res Public Health 2022; 19(13): 7599. http://dx.doi.org/10.3390/ijerph19137599 PMID: 35805256
[97] Ariyabuddhiphongs V. Buddhist belief in merit (Punña), Buddhist religiousness and life satisfaction among Thai Buddhists in Bangkok, Thailand. Arch Religionspsychol 2009; 31(2): 191-213. http://dx.doi.org/10.1163/157361209X424457
[98] Stankov L. Unforgiving Confucian culture: A breeding ground for high academic achievement, test anxiety and self-doubt? Learn Individ Differ 2010; 20(6): 555-63. http://dx.doi.org/10.1016/j.lindif.2010.05.003
[99] Nawrot KA. Does Confucianism promote cooperation and integration in East Asia? International Communication of Chinese Culture 2020; 7(1): 1-30. http://dx.doi.org/10.1007/s40636-020-00173-2
[100] 2022.https://www.state.gov/reports/2022-report-on-international-religious-freedom/thailand/
[101] Jeharsae R, Sangthong R, Wichaidit W, Chongsuvivatwong V. Growth and development of children aged 1–5 years in low-intensity armed conflict areas in Southern Thailand: a community-based survey. Confl Health 2013; 7(1): 8. http://dx.doi.org/10.1186/1752-1505-7-8 PMID: 23556430
[102] Blackburn AG, Taylor RW, Davis JE. Understanding the complexities of human trafficking and child sexual exploitation: The case of Southeast Asia. Women Crim Justice 2010; 20(1-2): 105-26. http://dx.doi.org/10.1080/08974451003641099
[103] Trinka E, Kwan P, Lee B, Dash A. Epilepsy in Asia: Disease burden, management barriers, and challenges. Epilepsia 2019; 60(S1) (Suppl. 1): 7-21. http://dx.doi.org/10.1111/epi.14458 PMID: 29953579
[104] Pendse R, Gupta S, Yu D, Sarkar S. HIV/AIDS in the South-East Asia region: progress and challenges. J Virus Erad 2016; 2 (Suppl. 4): 1-6. http://dx.doi.org/10.1016/S2055-6640(20)31092-X PMID: 28303199
[105] Sithinamsuwan P, Hutchings N, Ananworanich J, *et al*. Practice effect and normative data of an HIV-specific neuropsychological testing battery among healthy Thais. J Med Assoc Thai 2014; 97(0 2) (Suppl. 2): S222-33. PMID: 25518198
[106] Hemrungrojn S, Tangwongchai S, Charoenboon T, *et al*. Use of the montreal cognitive assessment thai version to discriminate amnestic mild cognitive impairment from Alzheimer's disease and healthy controls: Machine learning results. Dement Geriatr Cogn Disord 2021; 50(2): 183-94. http://dx.doi.org/10.1159/000517822 PMID: 34325427
[107] Kerr SJ, Puthanakit T, Malee KM, *et al*. Increased risk of executive function and emotional behavioral problems among virologically well-controlled perinatally HIV-infected adolescents in Thailand and Cambodia. J Acquir Immune Defic Syndr 2019; 82(3): 297-304. http://dx.doi.org/10.1097/QAI.0000000000002132 PMID: 31335589
[108] Wongchaisuwan T, Sithinamsuwan P, Udommongkol C, Wongmek W. Factors influencing MMSE-T score among Thai subjects. J Med Assoc Thai 2005; 88 (Suppl. 3): S155-8. http://www.jmatonline.com/PDF/S155-S158-PB-88-S3.pdf PMID: 16862678
[109] Jitapunkul S, Lailert C, Worakul P, Srikiatkhachorn A, Ebrahim S. Chula mental test: A screening test for elderly people in less developed countries. Int J Geriatr Psychiatry 1996; 11(8): 715-20. http://dx.doi.org/10.1002/(SICI)1099-1166(199608)11:8<715::AID-GPS374>3.0.CO;2-Q
[110] Saw YM, Saw TN, Than TM, *et al*. Cognitive impairment and its risk factors among Myanmar elderly using the Revised Hasegawa's Dementia Scale: A cross-sectional study in Nay Pyi Taw, Myanmar. PLoS One 2020; 15(7)e0236656 http://dx.doi.org/10.1371/journal.pone.0236656 PMID: 32722689
[111] Heaps J, Valcour V, Chalermchai T, *et al*. Development of normative neuropsychological performance in Thailand for the assessment of HIV-associated neurocognitive disorders. J Clin Exp Neuropsychol 2013; 35(1): 1-8. http://dx.doi.org/10.1080/13803395.2012.733682 PMID: 23113809
[112] Charernboon T, Jaisin K, Lerthattasilp T. The Thai version of the addenbrooke's cognitive examination III. Psychiatry Investig 2016; 13(5): 571-3. http://dx.doi.org/10.4306/pi.2016.13.5.571 PMID: 27757137
[113] Kamphinit PW, Tungkunanan P, Pimdee P, Sisan B. Thai student executive function: A confirmatory factor analysis (CFA). Journal of Positive Psychology and Wellbeing 2022; 6(2): 638-56.
[114] Tudor Hart J. The inverse care law. Lancet 1971; 297(7696): 405-12. http://dx.doi.org/10.1016/S0140-6736(71)92410-X PMID: 4100731

[115] Thalmayer AG, Toscanelli C, Arnett JJ. The neglected 95% revisited: Is American psychology becoming less American? Am Psychol 2021; 76(1): 116-29.
http://dx.doi.org/10.1037/amp0000622 PMID: 32271027

[116] Stefos E, Ortega DP, Valdivieso G. An analysis of key aspects of the illiterate Ecuadorian population Aged 15 years and older. Rev Eur Stud 2017; 9(3): 89-99.
http://dx.doi.org/10.5539/res.v9n3p89

[117] Phimarn W, Ritthiya L, Rungsoongnoen R, Pattaradulpithuk W, Saramunee K. Development and evaluation of a pictogram for Thai patients with low literate skills. Indian J Pharm Sci 2019; 81(1): 89-98.
http://dx.doi.org/10.4172/pharmaceutical-sciences.1000483

[118] Pluck G. Theory of mind ability and socioeconomic status, a study of street-connected children and adolescents in Ecuador. Psych 2021; 3(2): 72-84.
http://dx.doi.org/10.3390/psych3020008

[119] Chompukum P, Wongphaet P. Trail Making Test – Thai modification. Journal of Thai Rehabilitation Medicine 2007; 17(1): 26-30.

[120] Pluck G. Lexical reading ability predicts academic achievement at university level. Cogn Brain Behav 2018; 22(3): 175-96.
http://dx.doi.org/10.24193/cbb.2018.22.12

[121] Nelson HE, Willison J. National Adult Reading Test (NART). Windsor, UK: Nfer-Nelson 1991.

[122] Del Ser T, González-Montalvo JI, Martínez-Espinosa S, Delgado-Villapalos C, Bermejo F. Estimation of premorbid intelligence in Spanish people with the Word Accentuation Test and its application to the diagnosis of dementia. Brain Cogn 1997; 33(3): 343-56.
http://dx.doi.org/10.1006/brcg.1997.0877 PMID: 9126399

[123] Matsuoka K, Uno M, Kasai K, Koyama K, Kim Y. Estimation of premorbid IQ in individuals with Alzheimer's disease using Japanese ideographic script (*Kanji*) compound words: Japanese version of National Adult Reading Test. Psychiatry Clin Neurosci 2006; 60(3): 332-9.
http://dx.doi.org/10.1111/j.1440-1819.2006.01510.x PMID: 16732750

[124] Burgess PW, Alderman N, Forbes C, *et al*. The case for the development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. J Int Neuropsychol Soc 2006; 12(2): 194-209.
http://dx.doi.org/10.1017/S1355617706060310 PMID: 16573854

[125] Monsell S, Driver J. Banishing the control homunculus. 2000.
http://dx.doi.org/10.7551/mitpress/1481.003.0006