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TESIS DOCTORAL INTERNACIONAL

IMPACT OF CULTURE ON NEURODEVELOPMENT

IMPACTO DE LA CULTURA EN EL NEURODESARROLLO

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''That's the thing about human life;
there is no control group,
no way to ever know how any of us would
have turned out if any variables had been changed.''

— Elizabeth Gilbert

Si algo está claro, es que he llegado hasta aquí por aquellas variables que se han mantenido constantes durante este tiempo y, por la misma razón, debo mostrar mi agradecimiento a todas y cada una de ellas:

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RESUMEN/SUMMARY

RESUMEN

El objetivo principal de la presente tesis doctoral es estudiar el impacto de los sesgos culturales en el neurodesarrollo de los niños y niñas del mundo árabe. Para ello, la tesis se estructura de ocho capítulos agrupados en tres partes generales: una primera parte de introducción, una segunda parte empírica y, por último, una tercera parte de discusión, observaciones finales y recomendaciones futuras.

En la primera parte, se conceptualiza el término de cultura, cómo interacciona ésta con la cognición y el cerebro, y la historia y estado actual de la neuropsicología transcultural (Capítulo 1). Posteriormente, en el Capítulo 2, se profundiza en el papel de la cultura durante el neurodesarrollo infantil, los sesgos culturales que pueden influir en éste, y el estado actual e importancia del estudio poblaciones no occidentales, concretamente el mundo árabe, para una mayor comprensión del desarrollo sano y patológico infantil. Finalmente, en el Capítulo 3 se justifica el propósito de la tesis y se presentan los objetivos generales y específicos de la presente tesis.

La segunda parte consta de tres capítulos correspondientes a tres estudios científicos. En el primer estudio, Capítulo 4, se presenta un estudio de revisión de la neuropsicología transcultural mediante una técnica de *machine learning* para sintetizar y clasificar la literatura acumulada en el campo, encontrando una excesiva prominencia de estudios en Estados Unidos, lenguaje inglés, y cultura americana. En segundo lugar, los estudios con población adulta aparecen alrededor de tres veces más que los estudios con población infantil. Finalmente, se obtuvieron 25 temas de estudio recurrentes en el campo de la neuropsicología transcultural, entre los que destaca la evaluación neuropsicológica, entrenamiento y metodología, y el estudio de la demencia.

En el Capítulo 5, se estudian los sesgos culturales en la evaluación de la inteligencia infantil mediante la aplicación de una prueba no verbal, y supuestamente "libre de cultura" (Raven's Coloured Progressive Matrices; CPM), a una muestra de niños y niñas marroquíes de 7, 9 y 11 años con un desarrollo sano. El propósito del estudio fue comparar las puntuaciones brutas y transformadas (rangos y CI) de los participantes mediante los baremos de tres países no representativos: España, Omán, y Reino Unido. En general, estos baremos provocaron errores de clasificación, con los peores resultados al aplicar las normas de Reino Unido: el 15.68% de los participantes cayeron en el rango de "discapacidad intelectual" y el 62.50% "por debajo de la media". El CI transformado también se vio sesgado, especialmente con los baremos británicos y en edades superiores.

En el tercer y último estudio, Capítulo 6, se lleva a cabo un metaanálisis para estudiar el desarrollo de la inteligencia de niños y niñas entre 6 y 11 años en el mundo árabe, así como una comparación entre puntuaciones brutas y transformadas a CI mediante baremos no representativos británicos de la CPM. Mientras que el metaanálisis y las puntuaciones mostraron un desarrollo normal, con puntuaciones de inteligencia relacionadas positivamente con la edad, se encontró el efecto contrario al transformar estas puntuaciones a CI: mientras que a los 6 años el CI estaba alrededor de 100 puntos, este disminuyó con la edad hasta llegar a un CI de 62 (más de 2 desviaciones típicas por debajo de la media, considerado como supuesta "discapacidad intelectual") a los 11 años.

Finalmente, en la tercera parte, se discuten los resultados de manera general junto con sus consecuentes implicaciones teóricas y prácticas (clínicas y educativas) en el Capítulo

7, para concluir planteando una lista de observaciones finales y recomendaciones futuras basadas en los hallazgos obtenidos en el Capítulo 8.

SUMMARY

The main objective of this doctoral thesis is to study the impact of cultural biases on neurodevelopment of children from the Arab world. For this purpose, the thesis is structured into eight chapters grouped into three general parts: an introduction part, an empirical part, and finally, a third part based on the discussion, concluding remarks, and future recommendations.

The first part conceptualizes the term culture, how it interacts with cognition and the brain, and cross-cultural neuropsychology's history and current state (Chapter 1). Subsequently, Chapter 2 delves into the role of culture in child neurodevelopment, the cultural biases that may influence it, and the current status and importance of the study of non-Western populations, specifically the Arab world, for a better understanding of healthy and pathological child development. Finally, Chapter 3 presents the rationale and objectives of this thesis.

The second part consists of three chapters for three scientific studies. Chapter 4 presents a review of cross-cultural neuropsychology using a machine learning technique to synthesize and classify the accumulated literature in the field, finding an excessive prominence of studies in the United States, English language, and American culture. Studies with the adult population appeared about three times more than studies with non-adults. Finally, 25 frequent topics in the field of cross-cultural neuropsychology were obtained, among which neuropsychological assessment, training and methodology, and the study of dementia stand out.

In Chapter 5, cultural biases in the assessment of child intelligence are studied by applying a nonverbal and supposedly "culture-free" test (Raven's Coloured Progressive Matrices; CPM) to a sample of 7-, 9-, and 11-year-old Moroccan children with healthy development. The purpose of the study was to compare the participants' raw and transformed scores (ranks and IQ) using the norms from three non-representative countries: Spain, Oman, and the United Kingdom. Overall, these norms caused misclassification errors, with the worst results when applying the UK norms: 15.68% of participants fell into the "intellectual disability" range and 62.50% "below average." Transformed IQ was also biased, especially when using the UK norms at higher ages.

In the third study, Chapter 6, a meta-analysis is conducted to study the intelligence development of children aged 6-11 years in the Arab world, as well as a comparison between raw and transformed scores to IQ using non-representative British WPC scales. While the meta-analysis and scores showed normal development, with intelligence scores positively related to age, the opposite effect was found when transforming these scores to IQ: while at age 6, IQ was around 100 points, it decreased with age to an IQ of 62 (more than two standard deviations below the mean, considered as a presumed "intellectual disability") at age 11.

Finally, in the third part, the results are discussed with their consequent theoretical and practical (clinical and educational) implications in Chapter 7. Concluding remarks and future recommendations based on our findings are presented in Chapter 8.

PART I:

INTRODUCTION

CHAPTER 1:

Cross-Cultural Neuropsychology

Parts of this chapter were included in:

Lozano-Ruiz, A., Fasfous, A. F., Puente, A. E., Perez-Garcia, M., & Daugherty, J. C. (2023). *Is Cross-Cultural Neuropsychology Globally Representative? A Text Mining Review of the Literature*. [Manuscript submitted for publication]

CHAPTER 1:
Cross-Cultural Neuropsychology

Several neuropsychologists have explored the influence of culture on neuropsychological performance in recent decades (Ardila, 1995; Puente & Agranovich, 2013; Uzzell et al., 2013). However, culture has been defined in different ways by various fields, making it sometimes challenging to understand its relationship to neuropsychology. Given the multiple definitions, how can we comprehend this complex concept?

1. Definition of Culture

From a psychological perspective, Matsumoto & Juang (2004) define culture as "a dynamic system of rules, explicit and implicit, established by groups to ensure their survival, involving attitudes, values, beliefs, norms, and behaviors, shared by a group but harbored differently by each specific unit within the group, communicated across generations, relatively stable but with the potential to change across time." Although complex, this definition tries to operationalize in the most objective way possible the different dimensions other authors have proposed after thorough reviews (for example, the work by Soudijn et al., 1990, where they analyzed more than 100 definitions from different theorists).

The definitions proposed by other fields are closely related. For instance, Peoples & Bailey (2014) define culture from an anthropological perspective as "the socially transmitted knowledge and behavior shared by some group of people." On the other hand, Schein (1991) proposes a definition of culture from a sociological perspective structured in 6 points:

1. ”A pattern of shared basic assumptions,
2. invented, discovered, or developed by a given group,
3. as it learns to cope with its problems of external adaptations and internal integration,
4. that has worked well enough to be considered valid, and, therefore,
5. is to be taught to new members of the group
6. as the correct way to perceive, think, and feel in relation to those problems.”

Ardila (2017) proposes that “culture is the specific way of living of a human group,” covering three main dimensions:

1. internal, which refers to the subjective and psychological representation of culture, and which includes “thinking, feeling, knowledge, values, attitudes, and beliefs,”
2. behavioral, which includes how culture is expressed through interactions and relationships with others, and
3. cultural elements which are characteristic of a group (i.e., physical elements, such as instruments or clothes).

Furthermore, it is essential to clarify that culture is not a static entity, but rather it possesses a cyclical and dynamic nature. Culture can be seen as a constantly evolving process of adaptation that reinforces itself through a cycle of reciprocity. This process is influenced by various factors, including economic, political, and social conditions and technological and environmental changes (Hofstede, 2001).

In summary, culture is a complex and multifaceted concept defined and studied from various perspectives, including psychology, anthropology, and sociology. While there may be many different definitions of culture, they all highlight its central role in shaping human behavior and social relationships and its potential to evolve and adapt over time.

2. Cultural Neuroscience

Cultural neuroscience investigates the bidirectional interaction of culture, brain, and genes (Chiao & Ambady, 2007). In other words, it is an interdisciplinary field that combines anthropology, cultural psychology, neuroscience, and neurogenetics (Chiao et al., 2010). From this perspective, culture is perceived as an acquired ability for which the human being is neurobiologically prepared (Ames & Fiske, 2010).

To consolidate and conceptualize the accumulated evidence on these interactions, Li (2003; 2009) proposed a "cross-level dynamic biocultural coconstructivism" model framework (Figure 1). This way, developmental plasticity occurs simultaneously across levels and time scales. In other words, this takes place within the different lifespan stages through neurobiological, cognitive, behavioral, and sociocultural interactions. At the same time, bidirectional reciprocal biocultural influences are implemented throughout these interconnected processes of plasticity, thus conforming to this cross-level dynamic biocultural coconstructive framework.

Chiao et al. (2016) synthesized all the research in cultural neuroscience in a handbook, covering the study of lower- and higher-order processes: emotion, cognition, social cognition, intergroup processes, culture-genes interactions, and cultural disparities in health. For instance, differences have been found between individualistic and

collectivistic cultures in the serotonin transporter gene (5-HTTLPR) related to depression and anxiety (Chiao & Blizinsky, 2010), or in visual processing, finding object-processing (analytic) versus context-processing (holistic) styles for Westerns and East Asians, respectively (Goh & Park, 2009).

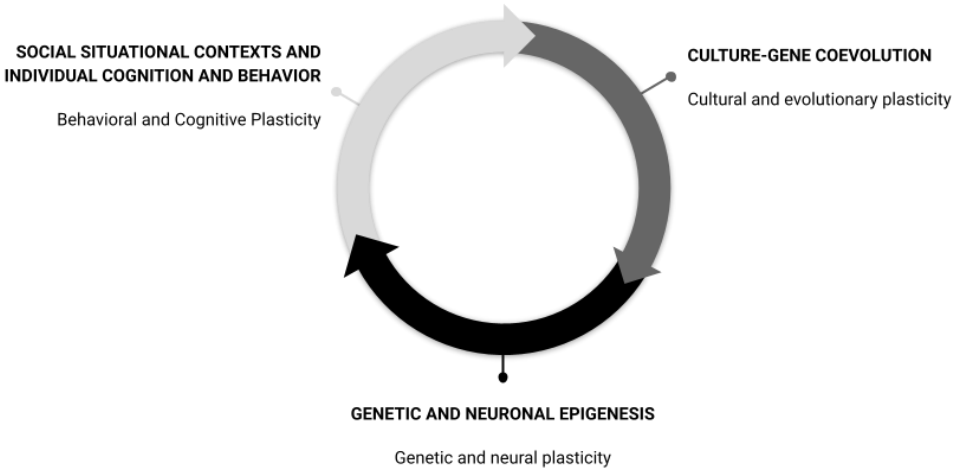

Figure 1. *Diagram of the cross-level dynamic biocultural coconstructivism framework. Adapted from Li (2003).*

One of the main purposes of cultural neuroscience is to reduce the research biases that currently exist in neuroscience, where most studies have been conducted exclusively in Western populations and do not consider cultural variables (Chiao, 2009; Chiao et al., 2010).

Cross-cultural neuropsychology could be considered a subfield within cultural neuroscience, primarily emphasizing the relationship between culture and neuropsychological function. This is the focus of this doctoral thesis.

3. Cultural Variables and Neuropsychological Performance

Puente & Agranovich (2013) state that "culture may play a much broader role than possibly age and education in shaping neuropsychological function." Despite its importance, the study of culture in neuropsychology has not always been a focus for all researchers, with some overlooking its significance.

Although the different cultural factors influencing neuropsychological functioning have yet to be objectively quantified, some authors have attempted to list the most important ones. According to Ardila (2007), cultural variables that may affect neuropsychology include patterns of abilities, cultural values, familiarity, language and differences in language, and schooling. Ardila (2020) also mentions acculturation as an important concept, although not directly a cultural factor.

Puente & Agranovich (2013) also point out five examples of trends in the field of cross-cultural neuropsychology: time, attitude toward testing, values and meanings, modes of knowing, and patterns of abilities.

The most relevant ones are summarized and explained below.

3.1. Patterns of Abilities and Modes of Knowing

The pattern of abilities refers to specific skills learned under a given culture, education, and environment. This may be reflected in the performance of neuropsychological tests and lead to differences between cultures or cohorts (Puente & Perez-Garcia, 2000). For example, in the Arab (Rugh, 2002), Ecuadorian (Bojorque et al., 2021) and Chinese (Li & Cutting, 2011) cultures, rote learning and "repeating pattern abilities" have been traditionally widespread, while other cultures and more recent approaches advocate for play-based pedagogies (Walsh et al., 2010).

Similarly, modes of knowing influence how we define cognitive skills and, consequently, how we create and develop tests to measure them. For instance, intelligence tests are primarily created in western cultures, giving more importance to reasoning and memory aspects than social aspects (van de Vijver & Tanzer, 2004).

3.2. Values, Meanings, and Familiarity

The concept we have about things, definitions and meanings can also affect neuropsychological performance. Ardila (2005) lists eight cultural values that can affect the psychometric properties of neuropsychological tests: one-to-one relationship, background authority, best performance, isolated environment, type of communication, speed, internal or subjective issues, and use of specific testing elements and testing strategies. These cultural factors are closely related to psychometric testing, as they can impact how we understand and interpret items or stimuli.

In this way, western tests can be misunderstood by non-western cultures even if these tests are nonverbal since stimulus characteristics such as shape, aesthetics, or geometry can influence the decisions made about the chosen response (Fernández & Abe, 2018).

Finally, familiarity refers to strategies and attitudes required to solve problems and success (Ardila, 2020), another factor closely linked to values and meanings. For instance, Fasfous et al. (2013b) found that familiarity with psychological tests caused cross-cultural differences in a nonverbal intelligence test between Spaniards and Moroccans, showing that the abilities required to perform the task differed across these cultures.

3.3. Attitudes Toward Testing

Attitudes toward testing can have both a positive and a negative influence on performance. For example, some cultures may not be accepting or consider appropriate to converse with strangers (Puente & Agranovich, 2013). On the other hand, Hispanics may perceive neuropsychological evaluation as a beneficial process in which they must be actively involved (Puente & Ardila, 2000).

3.4. Language

Language has always been one of the most striking cultural variables in psychology, partly because of the interest in bilingualism and its clinical implications in several neuropsychological disorders (Rosselli & Ardila, 2018).

Languages differ in complexity, grammar, and phonology and generally modulate how we perceive the world (Ardila, 2020). For instance, European languages vary considerably in complexity. While German and Finnish present the most complex morphology, Romance languages such as Italian, French, or Portuguese present morphologically simple structures (Sadeniemi et al, 2008). In the same way, Romance languages have a significantly more logical word order than Finno-Ugric languages, which have a very flexible word order. For this reason, language complexity can delay the acquisition and development of basic literacy skills (Spencer, 2007).

Similarly, different dialects of the same language can be spoken by similar cultures. For example, in the 22 countries of the Arab world, each has its dialect, with some being incomprehensible between Arab countries (Fasfous & Daugherty, 2022). Furthermore, some countries are multilingual due to Western colonization and speak their dialect

influenced by several languages, as in Morocco, where French is a language for formal contexts. In contrast, Dariya, an Arabic dialect, is used in informal and social contexts, the street and shops (Daniel & Ball, 2010). In short, language is not only a factor that distinguishes cultures and places, but also populations within the same or similar cultures.

Furthermore, reading habits can influence our conceptualization of temporal references. People who write from left to right (e.g., English or Spanish speakers) place the past on the left and the future on the right in their mental timeline. In contrast, right-to-left readers, such as Arabic or Hebrew speakers, place these temporal moments in reverse (Ouellet et al., 2010). Similarly, it has also been shown that these reading habits can affect aesthetic preferences of static and mobile objects in simple image stimuli (Chokron & De Agostini, 2000; De Agostini & Chokron, 2002). Thus, directional tendencies can also affect the way in which we respond to stimuli in a neuropsychological test (i.e., Rey-Osterrieth Complex Figure; Portex et al., 2017).

3.5. Education

Education is another variable that can differ across cultures and directly affects neuropsychological function and tests (Ardila, 2007). Years of formal education have been found to be positively related to multiple functions such as memory, working memory, or verbal and semantic fluency, among others (Ostrosky-Solís et al., 1999), even when tests are nonverbal (Rosselli & Ardila, 2003). On the other hand, illiteracy has an inverse influence on cognition, and extensive literature has found poor performance scores in most domains (Ardila, 2007; Julayanont & Ruthirago, 2018).

In contrast, the quality of education can also influence neuropsychological performance (Fernandez, 2022). Manly et al. (2002) demonstrated that the quality of education measured by reading skills improved the neuropsychological performance of older people compared to the number of years of education. Similar findings have been replicated in the decrease in cross-cultural differences when controlling for this variable (Cave & Grieve, 2009; Shuttleworth-Edwards, 2016). In this sense, complementing both level and quality is necessary (Fujii, 2018).

Secondly, the education system also varies across cultures and countries. For example, preschool education is not compulsory in some countries, such as Spain (Sandstrom, 2012), so not all children begin to have contact with formal learning before age 6. Moreover, cognitive style and learning strategies can also modulate cognition (Riding & Rayner, 2013). As explained before, patterns of abilities and modes of knowing, which are acquired at school stages, can affect how an individual plans and solves a task and the strategies we use to reach this goal. For example, Köster et al. (2020) found cross-cultural differences between German and Cameroonian children in developing new ideas, in favor of the first, where it was indicated that early access to individual thinking compared with repetition-based learning had a positive impact.

3.6. Attitudes Toward Time

The influence of our perception of time is a variable that has been studied very little in neuropsychology. Agranovich et al. (2007; 2011) found cross-cultural differences between Americans and Russians on attitudes toward time and explored how these may influence timed tests such as the Color Trail Test or the Ruff Figural Fluency Test. While American culture is used to time-based activities, Russian culture is based more on

"taking the necessary time," which may directly affect neuropsychological tests in which time is taken into account. Even more, half of the Russian sample reported never having a timed test. The authors found that Americans outperformed Russians in timed tests, while no differences were found on untimed tests. Therefore, time and the attitudes and familiarity we have toward it can influence neuropsychological performance.

3.7. Acculturation

Acculturation was defined by Redfield et al. (1936) as "those phenomena which result when groups of individuals having different cultures come into continuous first-hand contact, with subsequent changes in the original culture patterns of either or both groups."

Acculturation can be seen as either a one-dimensional process of adopting a new culture or as a bi-dimensional model that also considers the maintenance of an individual's original culture (Berry, 1997; Celenk & Van de Vijver, 2011). Based on this, there are four acculturation strategies that individuals may adopt: assimilation, marginalization, separation, and integration (Berry et al., 2003).

Assimilation involves abandoning one's original culture in favor of adopting a new cultural identity. In contrast, marginalization involves not only the rejection of one's own culture but also a lack of interest in adopting the dominant culture. These two strategies align with the adoption factor of acculturation.

Separation strategies involve maintaining one's own culture while ignoring the dominant culture. On the other hand, integration strategies involve the maintenance of an individual's original culture and adopting elements of the dominant culture. These

two strategies correspond to the maintenance factor and together, they form a bi-factorial model of acculturation (Berry et al., 2003).

Nevertheless, the mechanism behind acculturation's influence on neuropsychological performance is yet ambiguous. A systematic review by Tan et al. (2021) found heterogeneity in its effects, although there is evidence that it generally influences numerous verbal and nonverbal tests. Hence, it is important to consider acculturation when carrying out a neuropsychological assessment.

4. History of Cross-Cultural Neuropsychology

Although the earliest interest in the importance of cultural variables on cognitive performance could be attributed to Vygotsky, Luria's 1931 expedition to the Soviet Republic of Uzbekistan (Luria, 1933) likely catalyzed cross-cultural neuropsychology (Nell, 1999). The Uzbek investigations, which focused on studying the intellectual abilities of a group of peasants, were replicated in 1984 with almost the same results by Gilbert in KwaZulu, South Africa (1990). These findings suggested that the role of culture, and education, were possibly more critical than the actual state of the brain itself (Glozman, 2018). Unfortunately, in Nell's (1999) own words, Gilbert's findings "sank quietly into oblivion, ignored by the neuropsychologists and other students of cognitive processes who should be consulting them."

Due to the work of Luria or Gilbert, the impact of education and illiteracy on cognitive performance began to be of special attention to other researchers in the field, especially Alfredo Ardila (Ardila et al., 1989; Ardila et al., 1994; Ardila et al., 2010) and colleagues (Matute et al., 2012; Ostrosky-Solis et al., 1998; Ostrosky-Solís et al., 2004; Rosselli,

1993). These investigations were undoubtedly necessary for our understanding of cognitive and brain organization in normal and clinical conditions.

Ardila was also the first to officially introduce the term "cross-cultural neuropsychology" in a scientific article in 1993 (official year of publication: 1995). He played a leading role in the field, being the most influential researcher in the formalization of cross-cultural neuropsychology with his contributions. The author defined the discipline as the study of "the influence of cultural variables on cognition from a neurological perspective" (Ardila, 2020). His definition has brought to light issues which could be broadly covered in 3 major questions:

1. how cultural conditions affect neuropsychological tests,
2. how brain organization and cognition vary across cultures, and
3. whether neuropsychological pathologies are affected similarly depending on the culture.

Ardila (1995) concluded that "cross-cultural neuropsychology represents a critical new direction of research and will challenge neuropsychologists in the twenty-first century." The question remains, has Ardila's prediction come to pass?

5. Current Status of Cross-Cultural Neuropsychology

With the turn of the century, there was a resurgence of interest in cross-cultural neuropsychology. Three major books devoted to the field were published (Nell, 2000; Fletcher-Janzen et al., 2000; Uzzell et al., 2013). Other manuals about specific populations, such as Hispanics (Ponton & León-Carrión, 2001), Asian-Americans (Fujii, 2011), and other diverse minority groups (Ferraro, 2002), or multicultural mental health

(Paniagua & Yamada, 2013) contributed to the consolidation, thus establishing a firm theoretical pillar to advance research in the sub-specialty. Recently, in 2022, two new handbooks were published: one on the cultural influence on neuropsychological performance (Fernández & Evans, 2022) and another on ethnically diverse communities (Irani, 2022).

In addition to handbooks, other research emerged in a wide variety of topics and methodologies, such as the study of differences between cultures within the same country (Byrd et al., 2004) or between countries within the same culture (Buré-Reyes et al., 2013); the influence of time attitudes on neuropsychological assessment (Agranovich et al., 2011); the development of cross-cultural batteries for both children (Fasfous et al., 2015) and adults (Nielsen et al., 2019); or systematic reviews about the availability of neuropsychological tests in specific populations (Byrd et al., 2008; Fasfous et al., 2017; Rachel et al., 2021). Additionally, new methodologies have emerged with a particular focus on clinical implications, such as diagnostic errors and the misuse of norms (Daugherty et al., 2017; Lozano-Ruiz et al., 2021; Norman et al., 2011), or cultural considerations in forensic neuropsychology (Judd & Beggs, 2005).

The new emphasis on clinical improvement in recent years is also worth mentioning. Fujii (2018) proposed the ECLECTIC framework to improve neuropsychological evaluation in culturally diverse clients based on the following factors: "E: education and literacy; C: culture and acculturation; L: language; E: economics; C: communication; T: testing situation: comfort and motivation; I: intelligence conceptualization; and C: the context of immigration." Some authors are already implementing the ECLECTIC in pediatrics (e.g., Bordes Edgar et al., 2022; Moss & MacDonald, 2019), and others have

already pointed out its utility in diverse older populations in Europe (e.g., Franzen et al., 2022b; Nielsen, 2022).

Franzen et al. (2020) conducted a Delphi expert study on professionals in neuropsychology from nine European countries. The experts agreed that cross-culturally adapted tests and norms, as well as training and interpreters in clinical settings throughout the continent, are urgently needed. These findings led to the foundation of a European Consortium on Cross-Cultural Neuropsychology (ECCroN), whose mission is to improve "the assessment of diverse individuals across Europe through collaborations on test development, collection of normative data, cross-cultural clinical training, and interpreter-mediated assessment" (Franzen et al., 2022b).

In conclusion, culture is a broad and complex concept. Its influence on cognition and the brain is indisputable, and the interest in studying this interaction has been a growing trend in recent decades by professionals from different fields. Cross-cultural neuropsychology is an emerging discipline that explores how culture influences neuropsychological performance, what are the differences and similarities across cultures and contexts, and how neuropsychological pathologies are affected by culture.

CHAPTER 2:

Culture and Neurodevelopment

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Culture and Neurodevelopment

1. Neurodevelopment

Neurodevelopment refers to the process by which the brain grows and develops over time, starting from the early stages of gestation and continuing through childhood, adolescence (Spear, 2013), and early adulthood (de Graaf-Peters & Hadders-Algra, 2006). It encompasses a wide range of brain structure and function changes, including the formation of neural connections, the maturation of brain regions, and the development of cognitive abilities and behaviors (Munakata et al., 2004).

Neurodevelopment is a dynamic and ongoing process influenced by genetic and environmental factors (Martin et al., 2021; Munakata et al., 2004). Additionally, neurodevelopment can be affected by other factors such as stressful living and housing conditions, poor nutrition or inadequate health care (Rauh et al., 2008), and exposure to toxins (Andersen et al., 2000; Grandjean & Landrigan, 2014). All these harmful conditions can affect cognitive, physical, and social development, increasing disparities between children across populations (Rauh & Margolis, 2016).

Understanding the factors that shape neurodevelopment and the ways in which it changes over time is crucial for a range of disciplines, including psychology, neuroscience, and child development.

2. The Influence of Culture on Neurodevelopment

According to Li (2003), culture interacts with biology to shape our minds and behavior throughout our life. The coconstructivist paradigm proposed by this author has been put

into practice in concrete empirical studies. For instance, the work of Boivin & Giordani (2009) on African children suffering from cerebral malaria and HIV highlights the importance of biocultural bidirectionality and what they call "universal brain/behavior omnibus."

In this way, interactions with the environment within cultural contexts facilitate the maturation of mental constructs and neural mechanisms that are essential for the development of three different aspects: emotional, cognitive, and social development (Chiao, 2018). From cultural neuroscience, the development of emotion has been seen to be influenced by cultural styles of self-construal (individualistic versus collectivistic). Khan et al. (2017) propose a biocultural framework showing the different emotional domains influenced by culture, which may have a different developmental course across individuals: meanings, recognition, production, subjective experience, priming reactions, and genetic correlates.

Cultural styles of self-construal also can influence social processes, communication, perception and understanding of the self and others in early childhood, the formative processes of self and identity during adolescence, decision-making and social interactions in adulthood, and how individuals perceive and respond to emotions of others (Chiao, 2018).

Finally, culture can impact the neural basis of cognition, systems of thought (holistic versus analytic), infant knowledge of the world, executive functions, and, in interaction with genetics, mechanisms underlying the neurodevelopmental trajectory of cognitive processes (Chiao, 2018).

Therefore, the consideration of culture in the study of development, whether from the level of analysis of neuroscience, psychology, or neuropsychology, is crucial for an objective understanding of human development.

3. Cross-Cultural Differences in Child Development

Culture also plays a crucial role in consolidating cognitive development (Olson & Jacobson, 2015). However, few studies have delved into neurocognitive differences across cultures compared to those with adults.

Some investigations have studied cross-cultural differences by applying neuropsychological batteries covering the main cognitive domains (e.g., NEPSY-II; Korkman et al., 2007). For instance, Rosenqvist et al. (2017) found differences in neurocognitive performance between Finland, Italy, and the United States, being more pronounced at younger ages and alerting to different developmental curves across domains. For example, language and visual tasks were more culturally sensitive to culture than memory tasks. Other studies found similar results using the same battery (e.g., Mulenga et al., 2001; Westman et al., 2008) and other neuropsychological batteries (Pérez-García et al., 2019).

All these differences and similarities may be influenced by cultural influences on brain and cognitive maturation between cultures, resulting in different neurodevelopmental curves. According to Byrd et al. (2008), the cultural developmental patterns of children may follow a non-linear progression, thus following different rules that those of adults (Baron, 2010).

Despite these findings and the warnings by many authors about the applied and clinical need for knowledge in this field (Byrd et al., 2008; Miller & Kinsbourne, 2012; Olson & Jacobson, 2015; Rachel et al., 2021; Rosenqvist et al., 2017), research on cultural influences during cognitive development is still scarce.

4. Cultural Bias in Child Development

The importance of culture in cognitive development has been evidenced, but its applicability is even more critical for the practice of neuropsychology. Baron (2010) states that "a model of normal development provides critical clinical context." In this way, knowing how a child's normal development works can help understand neurodevelopmental problems better and create new instruments, diagnostics, and interventions.

As explained before, this typical development pattern is not stable across cultures. By analyzing the differences between cultures and considering how these may change with age, we can better tailor our approach to improve the effectiveness of neuropsychological instruments in different cultural contexts. However, before all that, we must ensure that what we measure and compare is free of cultural bias.

van de Vijver & Tanzer (2004) proposed three typical sources of bias: construct, method, and item bias. These should be considered in cross-cultural assessment during child development to allow for an indeed, effective evaluation.

4.1. Construct Bias

Construct bias occurs when the construct is not equivalent across cultures (Fernández & Abe, 2018). This can happen when the construct is not well-defined, skills required to measure the construct are not adequately considered across cultures, the construct is being underrepresented, or poor sampling (van de Vijver & Tanzer, 2004; Pedraza & Mungas, 2008). For instance, the concept of intelligence varies across cultures (Sternberg, 2007; Sternberg et al., 2001). Even more, neuropsychological abilities required to perform intelligence tests can also differ across cultures (Fasfous et al., 2013b).

4.2. Method Bias

Methodological issues can affect testing through three types of method bias: sample bias, administration bias, and instrument bias (van de Vijver & Tanzer, 2004).

Sample bias refers to the incompatibility of the sample caused by nuisance factors, such as motivation or differences in the educational system. For instance, Agranovich et al. (2011) studied cross-cultural differences between Americans and Russians, finding that the latest took more time to perform timed tests. This, however, was due to cross-cultural differences in attitudes toward time. If this had not been controlled, which in fact it was, since this was precisely the authors' purpose, sample bias could have been presented.

Administration bias includes environmental conditions of the assessment, test instructions, administrator expertise, and relationship and communication between the examiner and the examinee. For example, racial socialization can underestimate

children's neuropsychological performance due to the perceived stereotype threat (Olson & Jacobson, 2015).

Finally, instrument bias refers to familiarity with stimuli, response procedures, and response styles. These effects can be crucial when western tests are applied to non-western populations (Fernández & Abe, 2018).

4.3. Item Bias

Poor translation, nuisance factors, or inappropriate item content can cause differential item functioning. In other words, item scores can vary while the score is the same in the construct across cultures. Item bias can be improved through proper adaptation and validation (e.g., following the International Test Commission Guidelines; ITC, 2017), although a posteriori solution can be to replace the problem items (van de Vijver & Tanzer, 2004).

Another solution related to inappropriate content, which also can affect construct bias, is to avoid culture-specific stimuli and use widely applicable stimuli (Franzen et al., 2022b). For example, the Computerized Battery for Neuropsychological Evaluation of Children (BENCI; Fernández-Alcántara et al., 2022; Fasfous et al., 2015) includes tasks in which the stimuli are general animals (e.g., dog, horse, bird) that have been previously proven not to be specific to a particular geographic location (e.g., leopard).

5. Current Status of Child Development in Cross-Cultural Neuropsychology

Despite findings on cross-cultural differences during childhood, and the warnings by many authors about the applied and clinical need for knowledge in this field (Byrd et al.,

2008; Miller & Kinsbourne, 2012; Olson & Jacobson, 2015; Rachel et al., 2021; Rosenqvist et al., 2017), research on cultural influences during cognitive development, as well as culturally adapted tests, are still scarce in comparison to that in adults.

Rachel et al. (2021) reviewed the availability of culturally adapted neuropsychological tests among children aged 6-12. Most instruments were validated in the United States (46.40%) and very few in non-western and lower- and middle-income countries. For example, only 6 studies were found in Sub-Saharan Africa, and only 2 in the Arab world. Overall, most of the measures showed a lack of any of the psychometric properties or adequate adaptation.

Fasfous et al. (2017) already alerted about the low, though growing, availability of adequately developed, translated, adapted, and standardized tests in Arab countries, inciting the need for more work in the field due to the magnitude and heterogeneity of the Arab-speaking community. The importance of studying non-western cultures, such as the Arab world, could be a crucial point to understanding how cognition in children and adults is related to culture.

It is positive to note the increasing interest in recent years in the Arab child population. For example, Er-Rafiqi et al. (2021) studied the development of cognitive flexibility and planning skills in Moroccan children, in addition to working memory and inhibition (Er-Rafiqi et al., 2022). In both studies, the authors emphasize the lack of normative data, in this case of executive functions, and the need for such evidence to better understand development in North Africa. Similar findings are pointed out by Roukoz et al. (2021) in a study of Lebanese children's development.

6. Cognitive Abilities as a Proxy to Understand the Impact of Culture on Child Development

The importance of focusing on unstudied populations to understand the role of culture during cognitive development is now on the table. However, the results are heterogeneous across cultures, and most studies, either within the same context or across cultures, have focused on studying specific functions, being very few that tried to study cross-cultural differences in all cognitive domains (e.g., Pérez-García, 2019 or Rosenqvist et al., 2017).

For example, executive functions have been a central topic of interest and, simultaneously, a source of heterogeneity of results. A review by Schirmbeck et al. (2020) found 26 studies that investigated cross-cultural differences in the development of executive functions during childhood. They found cross-cultural differences but also a high disparity of outcomes because of the wide variety of tasks, subdomains, and applied measurement formats (direct versus parent or teacher rating assessment).

Ardila (2018) discusses the heterogeneity in executive functions and how these, when considered metacognitive functions, can be equivalent to intellectual abilities. For this reason, intelligence measures are widely used as a general measure of cognitive abilities worldwide. At the same time, the importance of intelligence during non-adult stages is crucial as a guide to normal development (Birney & Sternberg, 2006). Even in countries where neuropsychological testing is scarce or non-existent, the availability of intelligence tests is not as sparing (e.g., nonverbal intelligence tests in the Arab world; Fasfous et al., 2017).

However, this feasibility is a double-edged sword: the use of intelligence tests, both verbal and nonverbal, is widespread around the world either to estimate the development of cognitive skills, general executive functions, or simply intelligence. On the other hand, the availability of tests, especially nonverbal ones, make them cross cultures without prior adaptation and validation, which continues to be done despite having been warned decades ago (Greenfield, 1997).

Therefore, the use of intelligence tests can be beneficial from the point of view of cross-cultural neuropsychology to address two of the major problems: to study the influence of culture on cognitive development and to study the influence of culture on the performance and measurement of the test itself. In addition, the application of intelligence tests created in western cultures will be practical to understand how cultural variables, and more importantly, cultural biases, may affect cognition during development.

7. Impact of Culture on Child Development in the Arab World

The Arab world reached over 456 million people in 2021 (World Bank, 2022). Despite representing more than 5% of the world's population, even more than countries such as the United States, neuropsychological research in the Arab world is scarce and more common in adult populations (Fasfous et al., 2017).

As previously mentioned, studying new populations and cultures is beneficial for several reasons. First, it allows us to obtain new information on how culture may influence the development and study normal and pathological development in new contexts. Second, having new evidence in a previously unstudied culture allows us to develop the

profession of neuropsychology from theory and practice (e.g., developing new instruments). For instance, the number of culturally validated tests in the Arab child population is very limited and nonexistent in some Arab countries (Fasfous et al., 2017; Rachel et al., 2021).

In addition, studying the Arab population may be beneficial to better understanding different cultural biases. For example, the study by Fasfous et al. (2013b) found that familiarity with neuropsychological tests differed between Morocco and Spain, as children from one country and the other used different strategies to solve the same nonverbal intelligence test. These findings demonstrated how this familiarity with assessments can affect the evidence of the measured construct, but more importantly, this is a clear example of the advantages of studying child populations in non-western cultures, specifically the Arab world.

The present thesis focuses on the study of neurodevelopment in the Arab world, a population with an important and evident global representation, which requires further research and development of the profession, and which can also be useful and beneficial to better understand the role of culture in non-adult cognitive development.

CHAPTER 3:

Rationale and Objectives

CHAPTER 3:
Rationale and Objectives

As stated in the introduction, there is a substantial gap in publications and research focused on cross-cultural child neuropsychology (Byrd et al., 2008; Olson & Jacobson, 2015; Rachel et al., 2021). A few studies on this topic have found differences in the development of neuropsychological functions influenced by culture (Pérez-García, 2019; Rosenqvist et al., 2017). Additionally, other limited publications have focused primarily on comparing Americans versus other minorities in the United States or East Asians (Miller & Kinsbourne, 2012; Rosenqvist et al., 2017). Nevertheless, there is very little published work on cross-cultural neuropsychology in the Arab world (Fasfous et al., 2017), despite more than 456 million people across 22 countries coexisting (World Bank, 2022).

For all these reasons, the general objective of this doctoral thesis was to study the cultural biases in the intelligence assessment of children from the Arab world.

To achieve this general objective, the following specific objectives were established (Figure 1):

1. To study the state of cross-cultural neuropsychology through the distribution of countries, cultures, and languages studied, studies in children versus adults, as well as the most common topics of interest within the field.

To achieve this objective, a descriptive, objective review of the literature was carried out.

The results of this study can be found in Chapter 4 and were submitted for publication:

Lozano-Ruiz, A., Fasfous, A. F., Puente, A. E., Perez-Garcia, M., & Daugherty, J. C. (2023). *Is Cross-Cultural Neuropsychology Globally Representative? A Text Mining Review of the Literature*. [Manuscript submitted for publication]

2. To study whether cultural biases affect nonverbal intelligence tests in a sample of healthy Moroccan children.

Based on previous findings showing misclassifications and diagnostic mistakes when using non-representative norms in Moroccans (Daugherty et al., 2017; Fasfous et al., 2013b), the hypothesis was twofold: first, raw scores from the Moroccan children will differ from the normative data of other three countries with different cultural distance: Spain, Oman and the UK; second, IQ scores based on non-representative norms from these countries will result in the misclassification of Moroccan children.

The results of this study can be found in Chapter 5 and were published as a scientific article:

Lozano-Ruiz, A., Fasfous, A. F., Ibanez-Casas, I., Cruz-Quintana, F., Perez-Garcia, M., & Pérez-Marfil, M. N. (2021). Cultural bias in intelligence assessment using a culture-free test in Moroccan children. *Archives of Clinical Neuropsychology, 36*(8), 1502-1510. https://doi.org/10.1093/arclin/acab005

3. To study the consequences of applying western norms to the intelligence scores of Arab children throughout the 6-11 age range.

Previous research has shown an age-dependent increase in cognitive functions during childhood (Rosenqvist et al., 2017). However, some research has reported finding the

opposite effect in the Arab world (Bakhiet et al., 2018). Thus, the hypothesis was twofold: first, raw intelligence scores will increase as age increases; second, there will be a supposedly age-dependent decrease in intelligence when transforming raw data into IQ using non-representative, western norms.

The results of this study can be found in Chapter 6 and were submitted for publication:

Lozano-Ruiz, A., Fasfous, A. F., & Perez-Garcia, M. (2023). *The Misuse of Norms in Intelligence Testing: A Study and Meta-Analysis in Arab Countries* [Manuscript submitted for publication]

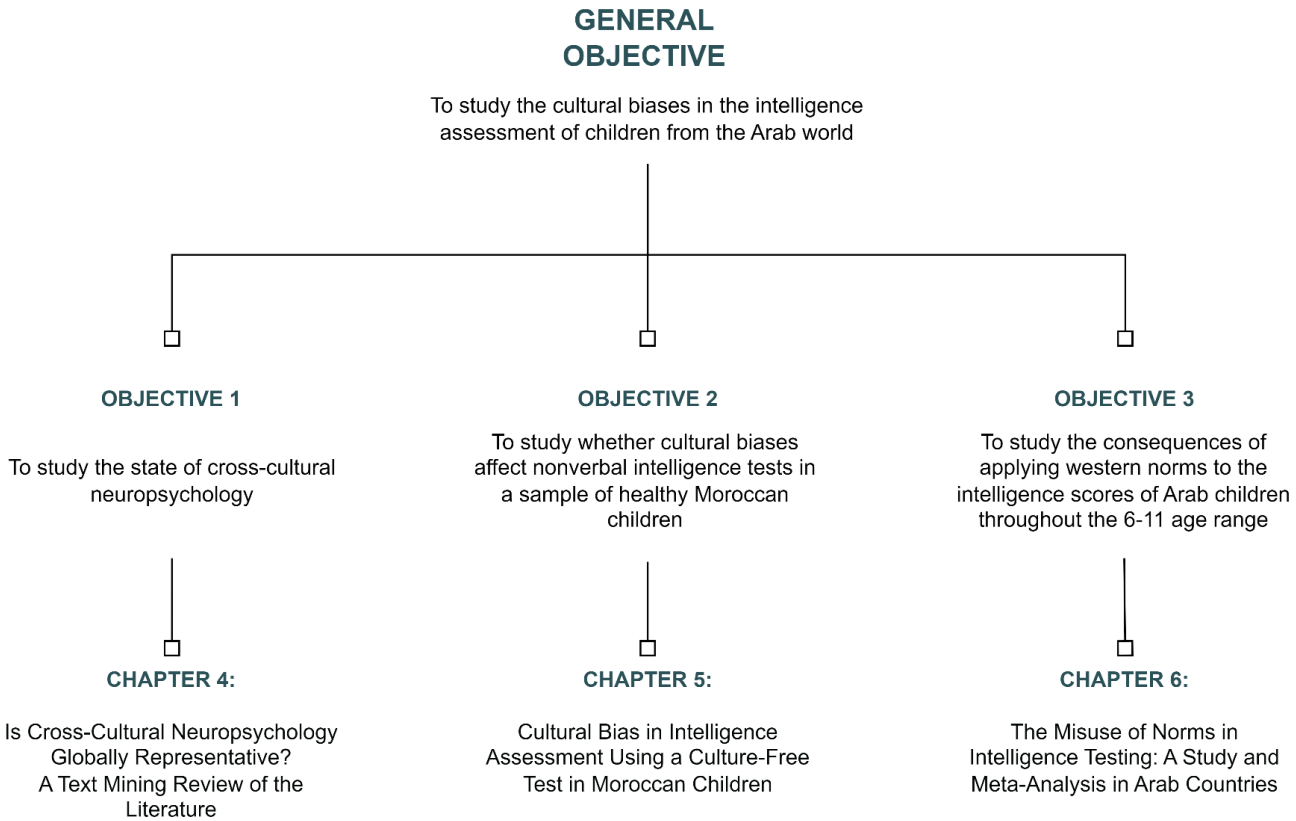

Figure 1. *General and specific objectives*

PART II:

EMPIRICAL RESEARCH

CHAPTER 4:

Is Cross-Cultural Neuropsychology Globally Representative? A Text Mining Review of the Literature

Lozano-Ruiz, A., Fasfous, A. F., Puente, A. E., Perez-Garcia, M., & Daugherty, J. C. (2023). *Is Cross-Cultural Neuropsychology Globally Representative? A Text Mining Review of the Literature*. [Manuscript submitted for publication in the *Journal of the International Neuropsychological Society*]

CHAPTER 4:
Is Cross-Cultural Neuropsychology Globally Representative? A Text Mining Review of the Literature

1. Introduction

After reviewing the psychological literature, Guthrie (2004) reported that "even the rat was white," reflecting a psychology that espoused a narrow and privileged view of the world. The question is now posed whether psychology's largest and fastest growing specialty, clinical neuropsychology, has similarly suffered from the same issues originally raised by Guthrie.

Although cross-cultural neuropsychology seems to have proliferated rapidly, objective information on the accumulated research in the field has yet to be brought to the table. In this sense, what are the actual topics studied in the field? Most importantly, has cross-cultural neuropsychology been adequately extended to various cultures -as its name implies-?

Most psychology research is conducted in WEIRD societies (i.e., Western, Educated, Industrialized, Rich, and Democratic), often assuming that it is sufficient to generalize to the rest of the cultures while ignoring cognitive and affective discrepancies (Henrich et al., 2010). According to Arnett (2016), most psychological research is concentrated in the United States, which accounts for only 5% of the global population. A recent update on this study concluded that World representation in top psychology journals has climbed to 11%, which is still deficient (Thalmayer et al., 2021).

Whereas these findings focus more generally on human behavioral sciences and psychology, information about neuropsychology is still lacking. Thus, two critical questions have emerged: 1) what cultures are more frequently studied in cross-cultural neuropsychology, and 2) what is the distribution of topics investigated in the discipline? To answer these questions, we pursued a topic modeling approach for conducting a machine learning-assisted review of the accumulated research in cross-cultural neuropsychology.

Thus, the objective of this study is twofold: first, to understand how cultures, ethnicities, and countries are represented in the literature, and second, to categorize the literature into topics. We hypothesize that the percentage of representation of non-American populations will be higher than that of Arnett (2016) and Thalmayer et al. (2021). It stands to reason that if we focus even more narrowly on the literature labeled as "cross-cultural," the prominence of American or WEIRD populations would be less extreme, or, at the very least, there would be more diversity and representation of other cultures.

2. Methods

A four-phased process was carried out (Figure 1): 1) search strategy and data gathering, 2) data preparation, 3) topic modeling, and 4) population classification.

We conducted the entire process and analysis using the R language, version 4.1.2 (R Core Team, 2021), and specific R packages mentioned throughout the procedure.

2.1. Search Strategy and Data Gathering

The search was conducted until January 2022 using four databases: PsycInfo, PubMed, Scopus, and Web of Science.

The search strategy was based on a combination of neuropsychology and words related to culture. For this step, we compiled and chose all cultural terms from the APA Thesaurus of Psychological Index Terms (Tuleya, 2007) included in PsycInfo to develop a final syntax adapted to each database. Only articles and book chapters in English were selected.

Finally, all outputs were downloaded as a bibliographic file containing information about the title, abstract, year, authors, and other metadata. The four databases were merged into a single database. A total of 1,065 records were obtained, of which 757 remained after removing duplicates, incomplete references, and other publications unrelated to the field (Figure 1).

Two researchers carefully screened this dataset to eliminate studies that did not fit cross-cultural neuropsychology using Rayyan software (Ouzzani et al., 2016), resulting in a total of 424 articles. Using the R package *citationchaser*, we conducted backward and forward citation chasing on these publications (Haddaway et al., 2022). After the manual filtering, all records cited by the included articles, as well as all records that cited these articles, were automatically retrieved. We then deduplicated and used the previously indicated procedure to screen for eligible articles, resulting in a final dataset of 1,337 documents.

All documents related to neuropsychological aspects from a cultural perspective were considered. Only peer-reviewed articles and book chapters were included.

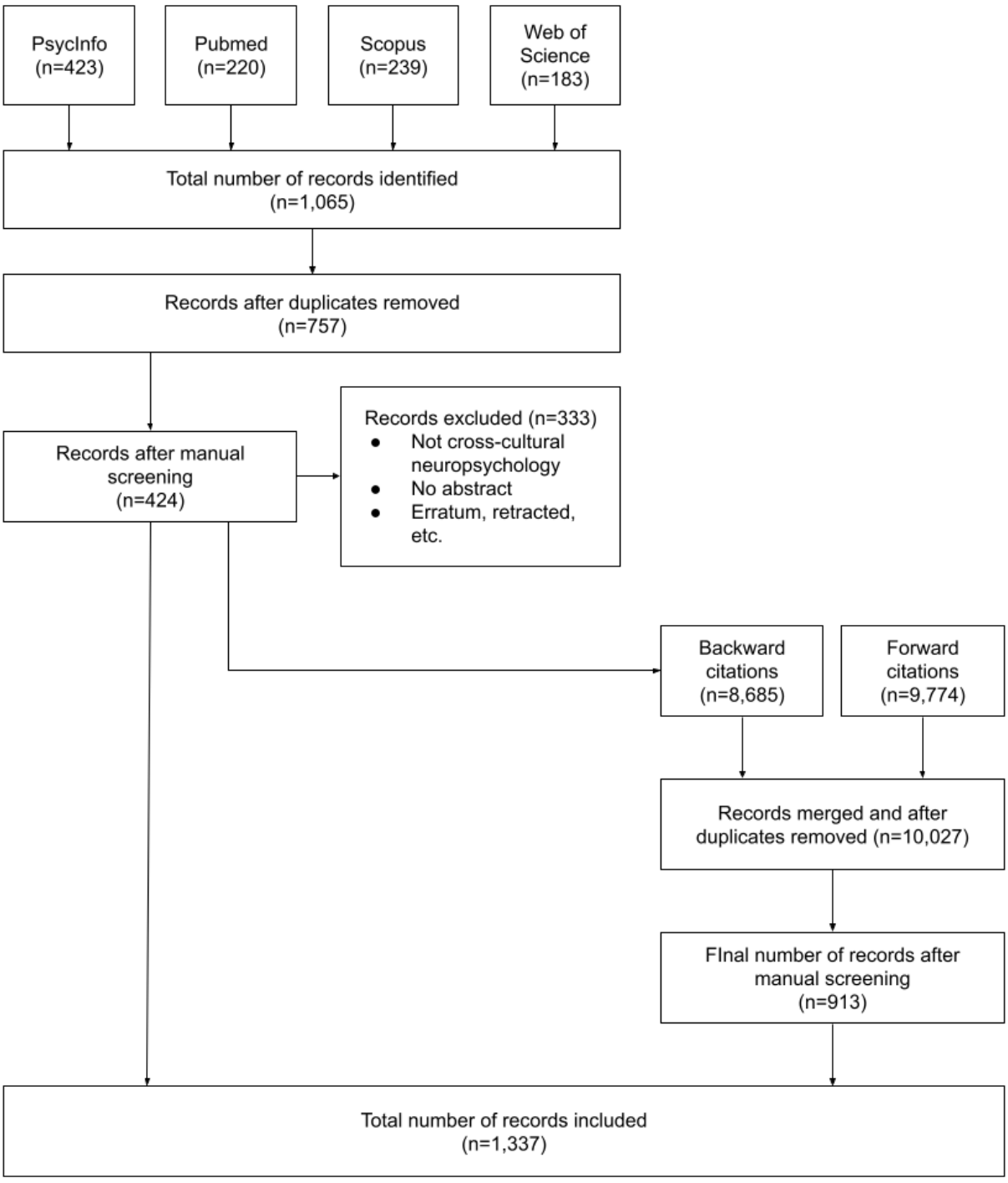

Figure 1. *Flow diagram*

2.2. Data Preparation

A rigorous pre-processing of the final dataset was carried out using the *textclean* R package (Rinker, 2018) to delete the publisher's information at the end of the abstracts. As titles can yield important complementary information, these were merged with abstracts into a single variable. Next, punctuation, double spaces, numbers, words with two or fewer characters, and *stopwords* (for details, see Benoit et al., 2021), such as the most frequent English words, abbreviations, contractions, prepositions, and action verbs, were removed using lists provided in the *qdapDictionaries* R package (Rinker, 2018). Further, commonplace multi-word expressions (e.g., "neuropsychological assessment") were compounded (e.g., *neuropsychological_assessment*) using the *quanteda* package (Benoit et al., 2018) to be counted as a single term. In parallel, the total number of articles published per year was calculated to provide additional helpful information.

Finally, a document-term matrix (i.e., the format required for topic modeling) was created, and the *tf-idf* (term frequency-inverse document frequency) was generated. The *tf-idf* is a statistical measure widely used in machine learning to avoid repeating irrelevant words (for more information and the formula, see Blei & Lafferty, 2009).

2.3. Topic Modeling

Topic modeling involves mining text from a large dataset of articles to quantitatively analyze semantic structures and patterns between documents. Using a three-level hierarchical Bayesian model called Latent Dirichlet Allocation (LDA; Blei et al., 2003), documents can be classified and analyzed efficiently (Blei & Lafferty, 2009) in a set of

topics, with the additional advantage in terms of time when dealing with vast amounts of information.

To define an optimal number of topics to generate based on our document-term matrix, we ran a diagnosis following the guidelines provided by Silge (2018). The diagnosis was based on four different parameters: exclusivity, semantic coherence, the likelihood for held-out datasets, and residuals. It is considered to be a good number of topics in an LDA model when the first three parameters are high (i.e., the topics are sufficiently distinguishable from each other and the terms within each are semantically related) together with low residuals. The optimum number of topics was k = 25.

Using the *topicmodels* package (Hornik & Grün, 2011), an LDA model setting k = 25 topics was run. Terms were assigned to topics based on beta values (i.e., "per-topic-per-word probabilities" or the probability of a term being found within a topic). Also, each document obtained gamma values (i.e., "per-document-per-topic probabilities," or the proportion of terms within a document that take part in a topic) (Silge & Robinson, 2017).

Although the process up to this point was entirely automated using unsupervised machine learning, we manually labeled each of these topics for better comprehension and to aid the understanding of readers and professionals using this article (Table 1). Two experienced researchers in cross-cultural neuropsychology applied their knowledge to the most important terms within each topic and, when necessary, checked texts assigned to each set of terms. When disagreements appeared, the authors collaborated with a third author to reach a consensus.

2.4. Population Classification

Four dictionaries were customized to account for the dataset's countries, languages, ethnicities, and child/adult distribution:

Countries were imported from https://datahub.io/core/country-list, an open-source list based on the official code list in ISO 3166-1, including 249 countries.

Languages were imported from https://datahub.io/core/language-codes, an open-source list based on the official code list in ISO 639-2, including 184 languages.

Ethnicities were imported from Gosselin (2022), an open-source list based on the U.S. Census Bureau and other official sources (see https://github.com/cgio/global-ethnicities for more information), including more than 700 ethnicities.

Finally, child- and adult-related words were included in another dictionary with two categories respectively. To create this, synonyms were searched in the Cambridge dictionary (https://dictionary.cambridge.org), and the root of these words was extracted (e.g., child*, infan*, adolescen*).

Then, using the *quanteda* R package (Benoit et al., 2018), these dictionaries were applied to our document-term matrix, allowing us to calculate frequencies across all documents. When a term appeared more than once in a document, it was only considered once.

3. Results

3.1. Publications by Year

Figure 2 shows the final dataset's frequency of documents by year. Production has increased over the last few decades, with minor ebbs and flows in recent years.

3.2. Population Classification

At least one nation was referenced in 479 of the 1,337 articles (35.83%). Of these, 128 mentioned the United States, which makes up 26.72% of the total articles, followed by China (6.89%) and the United Kingdom (5.22%). The rest of the countries appeared from 4 to 0%, and 70% of the countries in the World were not mentioned within these 479 documents (Figure 3).

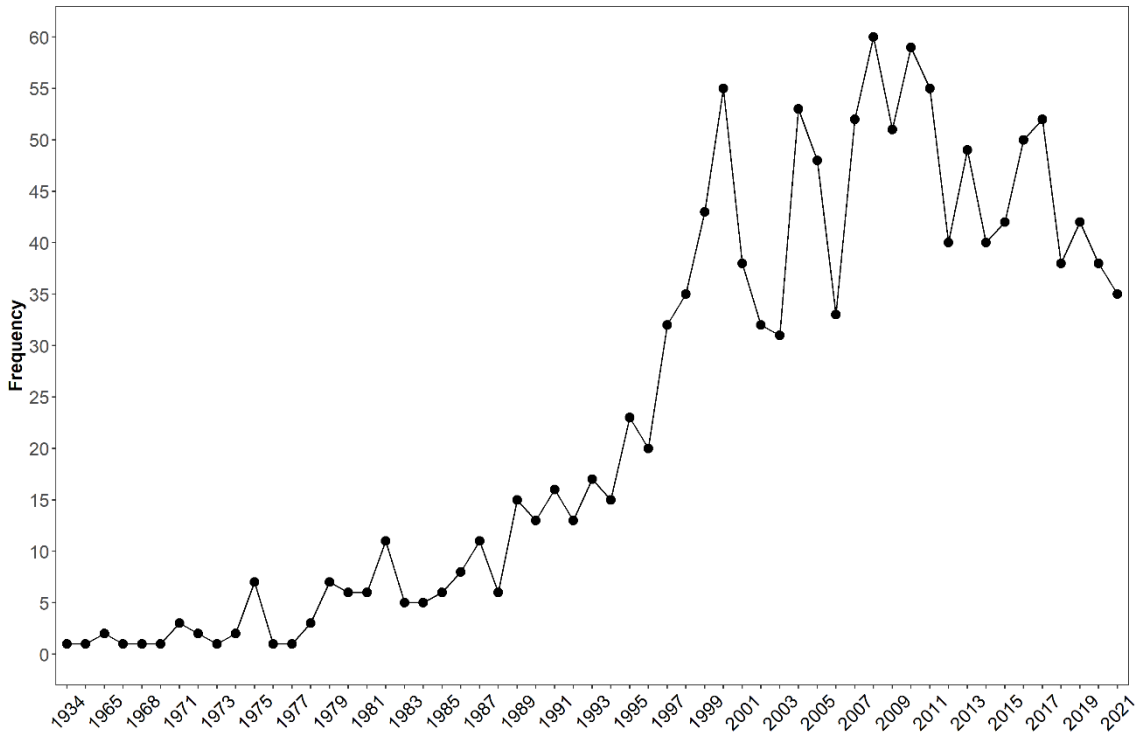

Figure 2. *Year distribution of publications*

When we analyze the distribution of languages, we find a similar pattern (Figure 3). At least one language was referenced in 585 of 1,337 documents. Of these, English

appeared 148 times (25.29%), followed by Chinese (13.33%) and Spanish (14.19%). The remaining languages appeared from 7 to 0%, and 27.72% were not mentioned within these 585 documents.

We found 1,177 out of the 1,337 articles mentioned at least one ethnicity (88.03%). Of these, 142 mentioned Americans (12.06%), followed by Hispanics (7.05%) and Chinese (6.62%). The other ethnicities appeared from 4 to 0%, and 17.61% were not mentioned within these 1,177 documents (Figure 3).

As can be seen in Figure 3, English, the United States, and the American culture are exponentially in the top 3 compared to the rest of the World population.

Finally, 667 documents explicitly included terms related to children or adults. Of these, 486 included adults (72.86%), and 181 included children-related terms (27.14%). In other words, children's studies appeared three times less than adult ones.

3.3. Topic Modeling

An LDA model of k = 25 topics was run. Table 1 shows all topics with their five most important terms, the topic label determined by the authors, and gamma values. Figure 4 shows topics ordered from high to low gamma values.

Topics related to culture & brain (topic 8), dementia screening (topic 5), assessment (topics 2 and 24), education (topic 14), and cognitive functioning in the elderly (topic 23) are the most frequent ones with gamma values over .05 (i.e., over a 5% of probability of appearing).

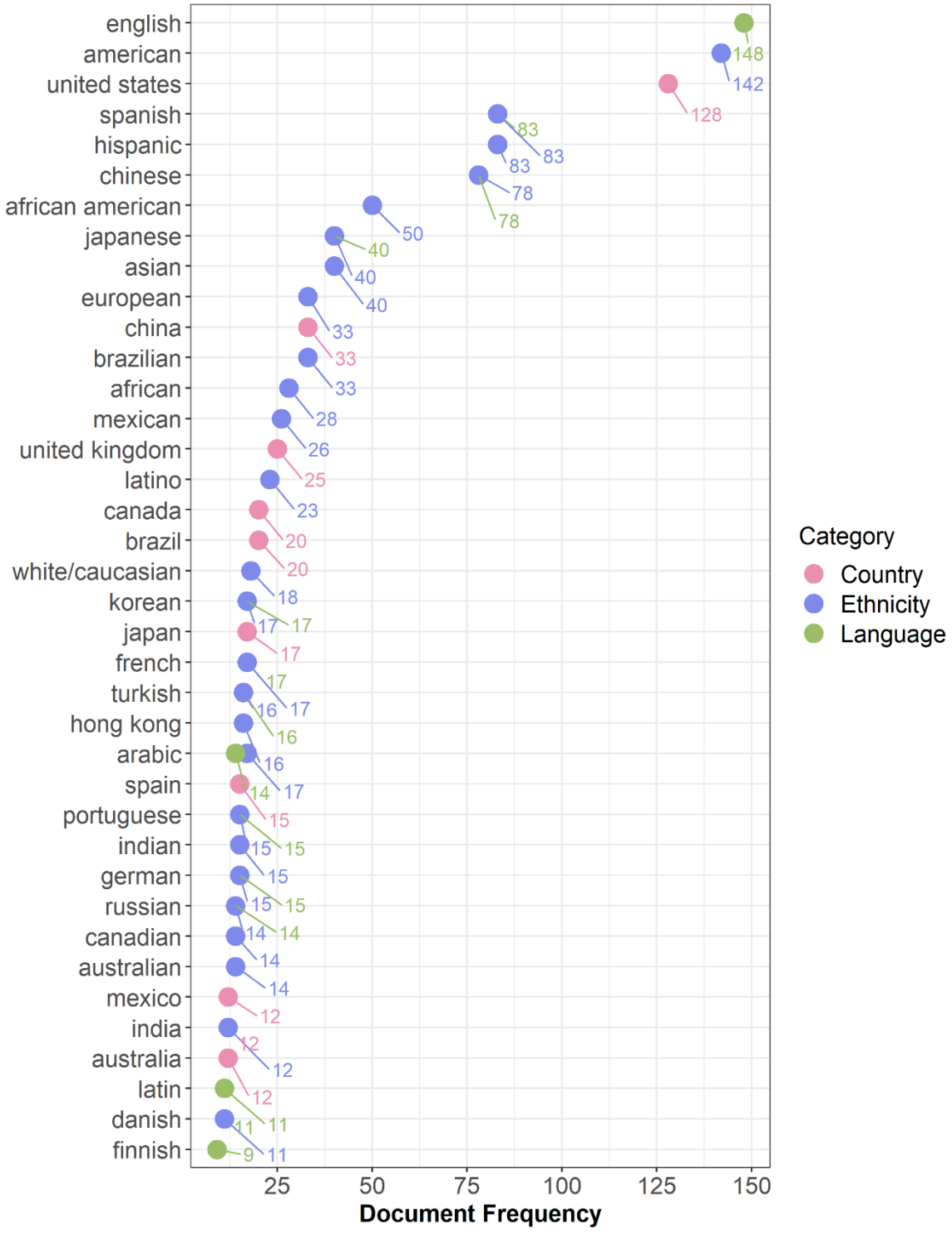

Figure 3. *Frequency of populations*

Topic 12 contains articles related to training, and together with topics 9 (tests & batteries), 1 (norms), 10 (validity & reliability), 16 (test performance), and 18 (cultural bias), we could identify a group of topics focused on methodology in cross-cultural neuropsychology. All of these topics appeared with a probability between 3.49-4.97%.

Intelligence (topic 11), memory (topic 6), executive function (topic 15), and spatial cognition (topic 3), from higher to lower gamma values, were the only cognitive functions easily recognizable as topics. Topics such as aphasia (topic 17), HIV (topic 7), or dementia (topics 5 and 20) highlight a clinical group, which also appears as a more general topic (topic 21), all of them ranging between 2.7-5.8%.

Furthermore, other topics, such as 22 (English speakers), 19 (illiteracy), and 4 (bilingualism), are focused on the study of language differences and the effect of literacy on cognition, mainly English-related. Further, topic 13 (Americans' neuropsychological performance) is linked to studying populations within American culture, interest related to the findings in the Population Classification section.

Finally, socioeconomic status (topic 25) was the topic with the lowest gamma value (.018).

Table 1. *Topics in Cross-Cultural Neuropsychology research*

Topic	Terms	Topic label	Gamma values
Topic 1	norms, scores, normative_data, normative, spanish-speaking	Norms	0.040
Topic 2	assessment, issues, neuropsychological_assessment, hispanic, cultural	Assessment	0.053
Topic 3	spatial, cognition, chinese, cognitive, numerical	Spatial Cognition	0.026
Topic 4	bilingual, bilinguals, bilingualism, cognitive, monolinguals	Bilingualism	0.025
Topic 5	dementia, mmse, screening, elderly, sensitivity_specificity	Dementia Screening	0.058
Topic 6	memory, fluency, verbal_fluency, verbal, tasks	Memory & Verbal Fluency	0.038
Topic 7	hiv, neurocognitive, impairment, hiv-associated, central	HIV	0.027
Topic 8	cultural, culture, brain, cognitive, social	Culture & Brain	0.066
Topic 9	tests, neuropsychological_tests, battery, cross-cultural, assessment	Tests & Batteries	0.044
Topic 10	validity, reliability, measures, clinical, scores	Validity & Reliability	0.037
Topic 11	intelligence, wechsler, scores, subtests, tests	Intelligence	0.048
Topic 12	neuropsychology, clinical, training, neuropsychological, development	Training	0.050
Topic 13	american, differences, performance, subjects, neuropsychological_performance	Americans' Neuropsychological Performance	0.028
Topic 14	education, effects, gender, performance, variables	Education	0.053
Topic 15	attention, working_memory, differences, processing, executive_functions	Executive Function	0.031
Topic 16	performance, groups, tests, differences, trail_making	Test Performance	0.036
Topic 17	japanese, reading, aphasia, recognition, stimuli	Aphasia	0.041
Topic 18	bias, items, factor, item, measurement	Cultural Bias	0.035
Topic 19	chinese, illiterate, subjects, literacy, literate	Illiteracy	0.035
Topic 20	dementia, ethnic, differences, minorities, minority	Dementia	0.036
Topic 21	patients, groups, controls, clinical, disease	Clinical Groups	0.035
Topic 22	english, speakers, languages, words, spanish	English Speakers	0.036
Topic 23	cognitive, older_adults, status, scores, differences	Cognitive Functioning in the Elderly	0.050
Topic 24	culturally, cultural, diverse, asian, neuropsychological_assessment	Assessment	0.058
Topic 25	ses, development, effects, socioeconomic_status, cognitive	Socioeconomic Status	0.018

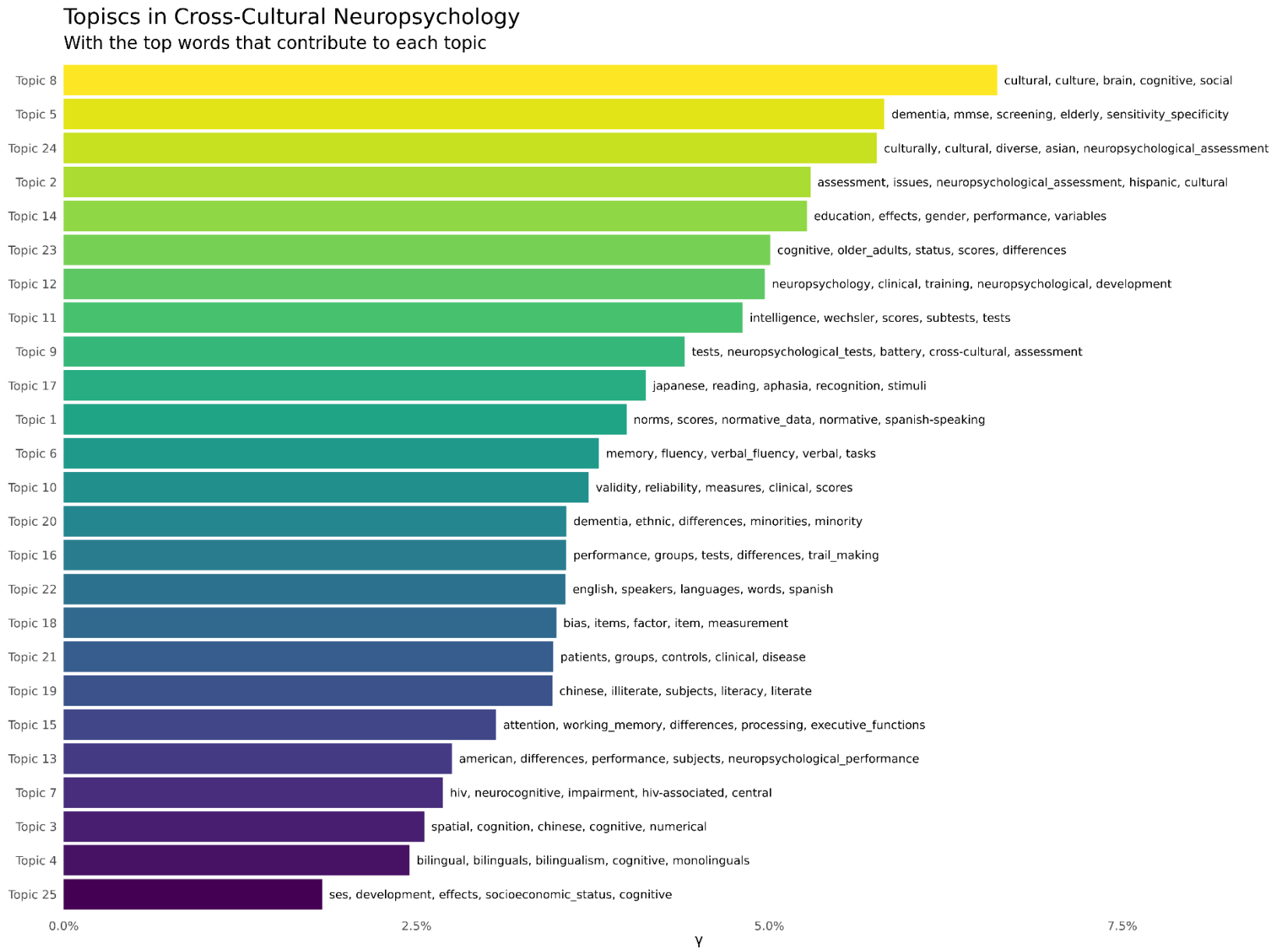

Figure 4. *Topics (k = 25) ordered by gamma values*

4. Discussion

Despite the growing interest in cross-cultural neuropsychology, no quantitative information about the accumulated research in this sub-specialty has ever been published. This is the first study to use Latent Dirichlet Allocation (LDA), a computer-based machine learning algorithm, to investigate the distribution of the populations and main topics studied in the field using a dataset of 1,337 peer-reviewed documents.

Our results on population distribution are only further evidence of a western, albeit colonial, predominance. The United States, the English language, and American culture appeared more often than any other nation or language. These results are comparable to Arnett's (2016), which was recently updated by Thalmayer et al. (2021). As the authors point out, most psychology papers focus on American culture, which accounts for only 5% of the world's population. In our dataset, the United States occupied a quarter of the studies, and 70% of countries had no representation in documents that mentioned a nation. It would have been logical for this predominance to be lower in our results since we examined culture-based literature, a more specific area of study than that of Arnett's findings for general psychology.

Similarly, 27.72% of languages and 17.61% of ethnicities were not mentioned. This approach does not support the standards espoused even by the American Psychological Association and related organizations (AERA, et al, 2014: Standards for educational and psychological testing). Surprisingly, and as stated before, this lack of representation is still prevalent in an area where a main, and increasingly critical objective, is to study the culture (Ardila, 2020). Undoubtedly, the rest of the world should play a more prominent role, and research should also be carried out in non-Western zones such as South

America, Asia, or Africa, where culturally adapted instruments are scarce or even nonexistent (Fasfous et al., 2017; Rachel et al., 2021).

At the same time, it is essential to highlight the small number of publications focused on child neuropsychology, which appeared three times less than adult research. Nearly two decades ago, Byrd et al. (2008) flagged the importance of culture on development and warned about the scarcity of cross-cultural tests for children. Rachel et al. (2021) also highlighted this issue a decade later, demonstrating a restricted number of tests available in low-to-middle-income countries (LMICs). There is now an accumulation of evidence supporting the need to investigate non-adult groups to better understand the relationship between culture and child development (Byrd et al., 2008; Olson & Jacobson, 2015).

Most of the topics in cross-cultural neuropsychology literature can be covered by the three main questions posed by Ardila (2020). In reference to the first question on how neuropsychological performance and tests are influenced by culture (Ardila, 2020), we identified topics related to training (topic 12), tests and batteries (topic 9), norms (topic 1), validity and reliability (topic 19), test performance (topic 16) or cultural bias (topic 18), which presented a probability of appearing between 3.49 and 4.97%.

Although there seems to be an interest in these issues at first glance, there are still some alarming gaps that should be further investigated. For example, although batteries and tests are being developed, and there is some interest in psychometric issues such as validity or reliability, it is well known that many non-Western populations have little or no assessment tools available. Along these lines, there are very few tests in the Arab world (Fasfous et al., 2017) or for child populations in LMICs (Rachel et al., 2021), and

those that exist lack methodological rigor, with high deficiencies in psychometric aspects such as adaptation, reliability, validity, and equivalence. Research shows that the use of non-representative norms can lead to diagnostic errors (Daugherty et al., 2017) or misclassifications (Lozano-Ruiz et al., 2021) in situations where appropriate standardized scores are not available for culturally diverse populations. Thus, there is a critical need for more research on cross-culturally sensitive, valid, and standardized neuropsychological tests, given the important practical implications for both research and clinical work alike.

Notably, there has also been a great emphasis in recent years on improving practice through training. Low professional training (Brickman et al., 2006) combined with the aforementioned inadequate practices may also lead to unfavorable situations for diverse populations. Approaches to assessing culturally diverse patients, such as the ECLECTIC framework proposed by Fujii (2018), and adapting tests in other populations to control for biases are indisputably necessary. In addition, guidelines for working with interpreters would be beneficial for improving neuropsychological assessment (Franzen et al., 2020; Franzen et al., 2022b).

Finally, in response to Ardila's first question, research has also examined other topics, such as bilingualism (topic 4), education (topic 14), illiteracy (topic 19), and socioeconomic status (topic 25) as factors influencing cognition. The first three are well-known objects of study, with findings on the effect of education and illiteracy on neuropsychological performance dating back to early research in the field (e.g., Ardila et al., 1989; Ardila et al., 2010). Socioeconomic status, while not directly cultural, has also been shown to have a negative impact on cognition (e.g., Noble et al., 2007; Tella

et al., 2018). It is, therefore, alarming that this topic was the least studied (1.8%) among those that were identified in the present study.

The second major question proposed by Ardila (2020), “what are the differences in the brain organization of cognition depending upon the culture” includes research on cross-cultural differences (such as those across nations, languages, ethnic groups, etc.) or differences within a population based on a particular cultural characteristic (e.g., North-South or urban-rural differences). Numerous studies have compared different populations, although, as we saw in the population distribution, there is a high probability that many of them include English-speaking or American populations in their studies. The cognitive functions found in our analysis of topics were intelligence (topic 11), memory (topic 6), executive function (topic 15), and spatial cognition (topic 3).

Intelligence is the most recurrent function across topics, likely the number of publications that attempt to compare different countries or cultures based on cognitive ability. It is important to note that many of these studies use nominally "culture-free" tests, which have not undergone cultural adaptations nor validity analyses in non-Western populations. This poses the consequent danger of producing misclassifications (Lozano-Ruiz et al., 2021) or the previously mentioned diagnostic errors. Another common mistake in these studies is the application of non-representative norms on IQ testing (e.g., applying UK norms to a non-Western sample), leading to construct invalidity, scientific racism, and biases in cognitive ability estimation (Ebbesen, 2020). Like any other neuropsychological test, intelligence tests should follow a systematic validation process (e.g., International Test Commission guidelines; ITC, 2017; Standards

for Educational and Psychological Testing; Wise & Plake, 2015) and not simply cross cultures, especially if created in the West (Greenfield, 1997).

Furthermore, the topic of brain organization across cultures that is largely unexplored in the field. In cultural neuroscience, some studies have differences in brain activity across cultures. For example, in an East Asian vs. Western sample, neuroimaging studies have assessed differences in brain activation during memory tasks (Gutchess & Indeck, 2009) and arithmetic processing (Tang et al., 2006). These studies can be categorized within topic 8 (culture & brain). However, very little research on this topic has been dedicated to assessing clinical samples and the neural underpinnings of differences in cognitive performance. This lack of research may be linked to methodological challenges, among which there is the need to minimize cross-site MRI scanner variation (Chiao et al., 2010).

Thirdly, cross-cultural neuropsychology explores how brain pathology is manifested in different cultural contexts. In other words, how cultural factors can influence different pathologies or whether differences in clinical populations are high or low among different cultures (Ardila, 2020). We detected several topics related to this question: topic 21 (clinical groups), topic 17 (aphasia), topic 7 (HIV), and topics 5 and 20 (dementia).

Aphasia has been one of the most commonly studied pathologies, likely due to its relationship with bilingualism (Johnson, 2020; Kotik-Friedgut, 2001) and illiteracy (e.g., Ostrosky-Solis et al., 1998), which were also identified as topics in our analyses. Dementia was, however, the most frequent clinical topic, appearing in topics 5 and 20, as well as partially related to topic 23 (cognitive functioning in the elderly). The

breakthrough in our field with dementia research is indisputable, with articles focusing on screening and diagnostic accuracy in multicultural populations (e.g., Basic et al., 2009; Nielsen et al., 2020; Rowland et al., 2006) or the development of cross-cultural instruments (e.g., Araujo et al., 2020; Nielsen et al., 2019; Franzen et al., 2022a; Storey et al., 2004). Nonetheless, the uniqueness of cultural, linguistic, and educational peculiarities in some parts of the world, such as Europe, involves new challenges (Nielsen, 2022).

Finally, a modest amount of research has also been dedicated to cultural considerations in the diagnosis of HIV-associated disorders (Rivera Mindt et al., 2019) and neuropsychological test performance of diverse HIV patients (e.g., Kamalyan et al., 2021; Siewe Fodjo, 2021). Despite the evident importance of this topic, it was very rarely recurrent (2.7%) in our analyses.

There are limitations to this study. First, it should be emphasized that there is no official or direct approach to finding publications on "cross-cultural neuropsychology," as this term is not an official keyword in any database. We used the backward and forward citation chasing technique to confront this problem and find all the possible publications in the field. To improve searches and give consistency to the discipline, we encourage databases and thesauruses to add this concept as a keyword. Further, some topics have not been explicitly mentioned because they are uncommon or appear so infrequently that they cannot be detected (e.g., forensics). Scoping and systematic reviews on specific topics within cross-cultural neuropsychology could be ideal for a more precise exploration. Finally, it should be noted that the fact that English is the language of science may also make it more likely to find articles in English-speaking populations.

Despite these limitations, this paper will contribute to cross-cultural neuropsychology by providing information on the most frequent populations and topics studied in the field.

5. Conclusions

This is the first study to gather published research on neuropsychology and culture to better understand the main populations and topics studied. Most research has been primarily conducted in English-speaking and American populations, as well as adults and older adults. More studies on children and the availability of evidence and empirical studies in non-Western cultures are required. These findings do not support the standards outlined by APA or even the aspirations of pioneers such as Luria and Ardila. In failing to achieve these aims, the results of the current investigation support the conclusion that neuropsychology, in general, and cross-cultural neuropsychology have not failed to reach their potential in the global theater but that the specialty of neuropsychology remains restrictive, non-generalizable, and limited in making an impactful and robust understanding of the brain. It appears not only that “even the rat was white,” but so is neuropsychology’s brain.

CHAPTER 5:

Cultural Bias in Intelligence Assessment Using a Culture-Free Test in Moroccan Children

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CHAPTER 5:
Cultural Bias in Intelligence Assessment Using a Culture-Free Test in Moroccan Children

1. Introduction

Despite the wide availability of data from different countries, cultures, and contexts, the influence of culture factors on cognitive abilities and intelligence performance, is still unclear (Georgas, 2003). This is especially apparent during child development stages (Fasfous et al., 2013a). According to Greenfield (1997), psychological tests are based upon the values and behavioral expectations of western societies in which they were developed, thus do not easily cross cultures. To highlight this point and prevent misinterpretation of test scores, Fujii (2017) recommended that performances on neuropsychological tests by diverse examinees should be referenced with "on western tests."

Sternberg (2004) argues that intelligent behavior is a culturally defined construct that is directly tied to addressing challenges in one's environment. This contention is supported by studies with Kenyans (Sternberg et al., 2001) and Alaskan Natives (Grigorenko et al., 2004) demonstrating that measures evaluating cultural specific characteristics of intelligence were a better indicator of everyday functioning than western-based cognitive tests. Moreover, performances on these tests were unrelated (Sternberg, 1990, 2007).

Numerous factors have been found to impact performance on western cognitive and intelligence tests which can account for cross cultural differences including socioeconomic status (SES) (Shuttleworth-Edwards et al., 2004; von Stumm & Plomin,

2015), and educational factors such as academic achievement (Deary et al., 2007; Strenze, 2007), parental education level and family social climate (Georgas, 2003), quality of education (Rindermann, 2008), and literacy (Ardila et al., 2010). The ubiquitous impact of such factors in addition to other social technological factors on test performances over time has been documented across the globe and referred to as the Flynn Effect (Flynn, 2012; Raven, 2000). Additionally, test results can be influenced by other subtle cultural factors, such as attitudes toward time (Agranovich et al., 2011), familiarity with previous psychological tests (Puente & Perez-Garcia, 2000), or urban/rural environments (Melikyan et al., 2020).

To reduce the impact of these cultural variables on intelligence assessment, "culture free" tests such as the Cattell Culture Fair Intelligence Test (Cattell, 1973), BETA-III (Kellogg & Morton, 1999), and Raven's Progressive Matrices (Raven, 1998) were developed (Cattell, 1940; Cattell et al., 1941). These tests were deemed "culture free" primarily due to the minimization of language requirements. However, studies with samples from different non-English speaking countries have consistently reported poorer performances when using U.S. norms (Daugherty et al., 2017; Fasfous et al., 2013b), suggesting that these nonverbal tests are influenced by cultural variables (Ardila, 2005; Rosselli & Ardila, 2003). Similar weaker performances have been found in different non-English speaking cultures when applying the normative standards of memory and executive function tasks in African Americans (Norman et al., 2011).

Raven's Coloured Progressive Matrices (CPM) is one of the most widely used "culture-free" cognitive ability tests for children between the ages of 5 and 11 (Raven et al., 1998). Although the first normative data were collected in 1942, currently the most

widely used norms come from a follow-up study conducted on 598 children from Dumfries, UK (1982). CPM has been used internationally, with norms from Spain (Raven et al., 2011), Australia (Cotton et al., 2005), South Africa (Linstrom et al., 2008), Brazil (Bandeira et al., 2004), and countries in the Arab world such as Oman (Kazem et al., 2009), United Arab Emirates (Khaleefa & Lynn, 2008), Libya (Lynn et al., 2008), Sudan (Bakhiet et al., 2017), and Egypt (Ziada et al., 2017).

Many studies, especially those conducted in the Arab world, still use the UK norms to interpret CPM to generate IQ scores (e.g., Bakhiet & Lynn, 2015; Bakhiet et al., 2017; Khaleefa & Lynn, 2008), often referred to as the "Greenwich IQ" (Bakhiet et al., 2018). However, this practice may be problematic due to the questionable appropriateness of using norms from another country to interpret test scores even for "culturally fair" tests (Daugherty et al., 2017; Norman et al., 2011). Additionally, some researchers have emphasized that one set of norms may not be applicable to the total population of a country, especially for multicultural countries. Instead, there should be multiple normative options (Oliveri & von Davier, 2016; Solano-Flores & Li, 2013). The clinical implications relating to the misuse and the unavailability of representative norms are extremely important, especially during a period of growth in migration and globalization in which we have reached the highest number of migrants in history (International Organization for Migration, 2018).

This study aims to examine the potential misclassification of intelligence in preadolescent Moroccan children when using non-representative norms to interpret the purportedly "culture free" CPM. Norms from UK, Spain, and Oman were selected due to contrasting cultural differences with Morocco. The first two countries belong to

Western societies that differ substantially from Morocco in language, SES (World Bank, 2020), and quality of education (Walsh et al., 2010; Organisation for Economic Cooperation and Development [OECD], 2019). Additionally, norms from these countries were selected for their clinical utility. CPM norms from the UK are the original and most widely used in previous research, whereas Spanish norms allow for practical application due to the large Moroccan immigrant population in this neighboring country (Migration Policy Institute, 2017). Oman is another Arab country sharing religion, language, values, and focus of education (El-Kogali & Krafft, 2019) with Morocco, although the economy is stronger. The inclusion of this Middle Eastern country provides a contrast with countries that are culturally similar (Buré-Reyes et al., 2013).

We hypothesize: 1) raw scores from the Moroccan children will differ from the normative data of the other three countries; and 2) IQ scores based on non-representative norms will result in an over-classification of Moroccan children in lower ranges versus the normal curve.

2. Methods

2.1. Participants

One hundred forty-seven school children ages 7 (*n* = 51; 25 boys and 26 girls), 9 (*n* = 48; 23 boys and 25 girls), and 11 (*n* = 48; 22 boys and 26 girls) from two middle class schools in Chefchaouen were included in this study. This northern city is representative of the culture and socio-economic conditions in Morocco which is based in tourism and trade (Fasfous et al., 2015). Children in each age group were similar in sociodemographics such as academic achievement, parental education, and parental employment status (Table

1). There was no evidence of cognitive, psychological, or physical impairment in the participants which is further supported by typical placement of Moroccan children with developmental problems in adapted schools. Demographic information was procured in interviews with parents and teachers.

A power analysis for a one-way analysis of variance was conducted using the following parameters: number of groups k = 3, Cohen's f = .4, significance level at .01, and a minimal power of 80%. The effect size corresponds to a large effect, according to Cohen (1988). An estimated sample size of at least n = 30 for each group was obtained. Thus, our sample provided adequate power for analysis.

2.2. Instrument

The Raven's CPM (Raven et al., 1998) is a nonverbal test of intelligence commonly used for the assessment of 5- to 11-year-old children, as well as elderly people. This task consists of 36 items of increasing difficulty, which include an incomplete pattern with six options below it, of which only one is correct. The total score is recorded and classified into ranges based upon percentiles: range I = intellectually superior (above the 95th percentile); range II = above average (between the 75th and 95th percentile); range III = on average (between the 25th and 75th percentile); range IV = below average (between the 5th and 25th percentile); range V = intellectually impaired (under the 5th percentile). Alternatively, IQ scores can be calculated from normative data. For this study, the norms from the UK (Raven et al., 1998), Spain (Raven et al., 2011) and Oman (Kazem et al., 2009) were used. While the reliability data for the British sample was unavailable, the CPM has shown adequate psychometric properties in Spanish children with a high Kuder–Richardson reliability index (K-21) equal to .92, a split-half reliability

of .87, and a test–retest reliability of .71 (Gómez Fernández, 1982). For the Oman study, a Cronbach's alpha of .88, a split-half reliability of .78, and a test–retest reliability of .56 were reported (Kazem et al., 2009). By contrast, Cronbach's alphas of .88, .90, and .89 for the 7-, 9-, and 11-year-olds have been specifically presented. Considering these and other reliability analyses conducted on the CPM in other countries, an average of around .80 has been estimated (Cotton et al., 2005).

2.3. Procedure

The Delegation of Education of Chefchaouen selected two middle-class schools based on demographic and SES data. From each of the schools, two classes from grades 2 (7-years-old), 4 (9-years-old), and 6 (11-years-old) were selected. Applying stratified sampling method to class rosters, the sample was subdivided considering gender and academic achievement at three levels (low, medium, and high), and then the children were randomly drawn from each stratum. Testing was conducted by an Arabic-speaking neuropsychologist in a classroom at each of the schools during academic hours. All participants were assessed with the paper-pencil CPM that followed the instructions for the individual administration of this test (Raven et al., 1998). The total number of correct items was recorded. The Research Ethics Committee at the University of Granada approved this study. Formal permission to conduct the study in the two schools was obtained from the Delegation of Education of the city and the schools' directors. The participation of the selected students was voluntary, and informed consent was obtained from parents.

Table 1. *Sociodemographic variables of the Moroccan sample*

	Total (*N* = 147)	7-year-olds (*n* = 51)	9-year-olds (*n* = 48)	11-year-olds (*n* = 51)	Age differences
Gender (*n*)					
Boys	70	25	23	22	$\chi^2 = .103$
Girls	77	26	25	26	$p = .95$
Children's academic achievement[a] (*M, SD*)	6.93 (1.32)	6.84 (1.16)	7.07 (1.42)	6.88 (1.4)	$F = .4$ $p = .667$
Father's years of formal education (*%*)					
Less than 6 years	57.8%	58.8%	58.3%	56.2%	$\chi^2 = .67$ $p = .955$
Between 6-12 years	25.9%	25.5%	22.9%	29.2%	
More than 12 years	16.3%	15.7%	18.8%	14.6%	
Mother's years of formal education (*%*)					
Less than 6 years	70.8%	68.6%	75%	68.7%	$\chi^2 = 5.07$ $p = .28$
Between 6-12 years	22.4%	23.5%	14.6%	29.8%	
More than 12 years	6.8%	7.8%	10.4%	2.1%	
Father's employment status (*%*)					
Self-employment	29.3%	31.4%	25%	31.3%	$\chi^2 = 13.67$ $p = .322$
Family Business	2.7%	3.9%	0%	4.2%	
Unskilled Manual Labor	14.3%	15.7%	8.3%	18.8%	
Manual Labor	2.7%	3.9%	0%	4.2%	
Domestic Labor	0.7%	0%	2.1%	0%	
Employee	35.4%	33.3%	39.6%	33.3%	
Unemployed/Housewife	15%	11.8%	25%	8.3%	
Mother's employment status (*%*)					
Self-employment	3.4%	2%	2.1%	6.3%	$\chi^2 = 10.15$ $p = .603$
Family Business	1.4%	0%	2.1%	2.1%	
Unskilled Manual Labor	1.4%	0%	2.1%	2.1%	
Manual Labor	0.7%	2.7%	0%	0%	
Domestic Labor	6.1%	5.9%	4.2%	8.3%	
Employee	6.8%	3.9%	12.5%	4.2%	
Unemployed/Housewife	80.3%	86.3%	77.1%	77.1%	

Note. [a] Grade point average (maximum of 10) during the academic year

2.4. Statistical Analysis

To compare CPM group differences for Moroccan children, chi squares were conducted to compare demographic data, and a one-way ANOVA was conducted with post-hoc comparisons with a Bonferroni correction adjusted to α = .017. Multiple one sample t-tests were performed to compare scores for Moroccan children with the other groups using their norms. As the means and standard deviations of the three age groups were not available from the UK norms, the following formula proposed by Luo et al. (2018) was used to estimate the means by each age group's percentiles: $M = [0.7+(0.39/n)] \times [(q_1 + q_3)/2] + [0.3 – (0.39/n)]m$, where q_1 is the first quartile (25th percentile), q_3 is the third quartile (75th percentile), and m is the median (50th percentile). For the SD estimations, the equation proposed by Wan et al. (2014) was applied: $SD = (q_3 - q_1)/\eta(n)$, where $\eta(n)$ is a varying value given in Wan et al. (2014). These equations have been proven to be the most accurate method of estimation for sample distributions close to normality (McGrath et al., 2020). To control for potential inaccuracies due to the need to use calculations compare the UK data, confidence intervals for the Moroccan scores were adjusted to 99%. Additionally, effect sizes were also reported using the Cohen's *d* (Cohen, 1988).

Finally, to determine misclassification, the norms from these three foreign countries were used to transform the Moroccan total CPM scores into ranges and IQ, especially focusing on the appearance of intelligence deficiencies. All statistical analyses were performed using the R statistical software (R Core Team, 2020), with the addition of the *Basic Statistics and Data Analysis (BSDA)* package (Arnholt & Evans, 2017) for the cross-cultural comparisons.

3. Results

3.1. Moroccan Data

No significant differences were found for parent's education and occupation status for the three age levels (see Table 1). The means and standard deviations of scores for the three age groups in Morocco are presented in Table 2. A one-way ANOVA reported significant differences between the three groups ($F = 21.15$, $p < .001$). Bonferroni post-hoc comparisons indicated

significant differences between the 7- and 9-year-olds ($p < .001$) and the 7- and 11-year-olds ($p < .001$), in favor of the older groups (Table 2). However, no significant differences were found between children ages 9 and 11 ($p = .417$).

3.2. Cross-Cultural Differences

Multiple one sample t-tests were conducted to compare the Moroccan data with normative data from the UK, Spain, and Oman (see Table 3). When comparing Moroccan and the UK children, significant differences were only found in the 11-year- old group with UK children demonstrating higher scores ($t = 6.118$, $p < .001$, d = 1.197). Significant differences were also found between Morocco and Spain, with higher scores for Spanish children in both 7-year-old ($t = 2.965$, $p = .003$, $d = .421$) and 9-year-old groups ($t = 2.785$, $p = .005$, $d = .417$). No comparisons were made with the 11-year-old group, as there is no published data for this age group in Spain. Finally, when comparing the two Arab countries, differences were only found in the 9-year-old group with the Moroccan children scoring higher than the Omani group ($t = 2.595$, $p = .01$, $d = .455$).

Table 2. *Raw means, standard deviations, and a one-way ANOVA between age groups in the Moroccan sample*

	CPM Total Score				ANOVA			
Age (years)	***n***	**M**	**SD**	**95% CI**	***F* ratio**	***p***	**Partial η^2**	**Posthoc**
7	51	20.92	6.48	[19.1, 22.74]				
9	48	26.04	5.35	[24.49, 27.6]	21.15	< .001	.227	7 < 9* 7 < 11*
11	48	27.69	5.35	[26.5, 28.87]				

Note. CPM = Raven's Coloured Progressive Matrices; CI = confidence interval; ANOVA = analysis of variance.

* $p < .001$

Table 3. *Cross-Cultural comparisons between Morocco and UK, Spain, and Oman*

	Morocco	**UK[a]**	**Spain[b]**	**Oman[c]**	**Morocco vs. UK**		**Morocco vs. Spain**		**Morocco vs. Oman**	
Age (years)	**M (SD)**	**M (SD)**	**M (SD)**	**M (SD)**	***t***	***d***	***t***	***d***	***t***	***d***
7	20.92 (6.48)	20 (4.57)	23.68 (6.53)	20.20 (6.50)	.849	.164	-2.965**	.421	.682	.118
9	26.04 (5.35)	27.64 (5.39)	28.32 (5.59)	23.25 (6.82)	-1.363	.298	-2.785**	.417	2.595**	.455
11[d]	27.69 (4.08)	32 (3.05)	-	26.39 (6.37)	-6.118***	1.197	-	-	1.34	.243

Note. UK = United Kingdom; *d* = Cohen's d effect size.

[a] Sample size for UK: n(7) = 55; n(9) = 37; n(11) = 55.

[b] Sample size for Spain: n(7) = 1373; n(9) = 1490.

[c] Sample size for Oman: n(7) = 137; n(9) = 154; n(11) = 177.

[d] No data published for the 11-year-olds in Spain.

*$p < .05$; **$p < .01$; ***$p < .001$.

3.3. Misclassifications

Norms from the UK, Spain, and Oman were used to transform the total CPM score of each subject into ranges through the procedure presented in manual (Raven et al., 1998). Frequencies were computed to pay explicit attention to the percentage of subjects falling into the ranges IV ("below average," under the 25th percentile) and V ("intellectual impaired," under the 5th percentile) (Figure 1). IQ was also calculated using the norms of the three foreign countries for each age group (Figure 2).

3.3.4. Applying the norms of UK

When the original norms from the UK were applied to the 7-year-old children, 23.53% were classified as "below average" (range IV), and 15.69% of them were classified as "intellectually impaired" (range V). In the 9-year-old group, 29.17% fell "below average" (range IV), and 6.25% presented as "intellectually impaired" (range V). Finally, 62.5% of the 11-year-olds were classified as "below average" (range IV) and 10.4% as "intellectually impaired" (range V). Using the same UK norms, the IQ mean for the 7-year-old group was 103, 96 for the 9-year-old group, and 79 for the 11-year-olds.

3.3.5. Applying the norms of Spain

When the norms from Spain were applied to the Moroccan 7-year-old group, 25.49% of the children fell "below average" (range IV) and 15.68% were classified as "intellectually impaired" (range V). For the 9-year- old group, 22.92% were classified as "below average" (range IV) and 12.5% were "intellectually impaired" (range V). When calculating IQs, both 7- and 9-year-old Moroccan children earned an IQ score of 94.

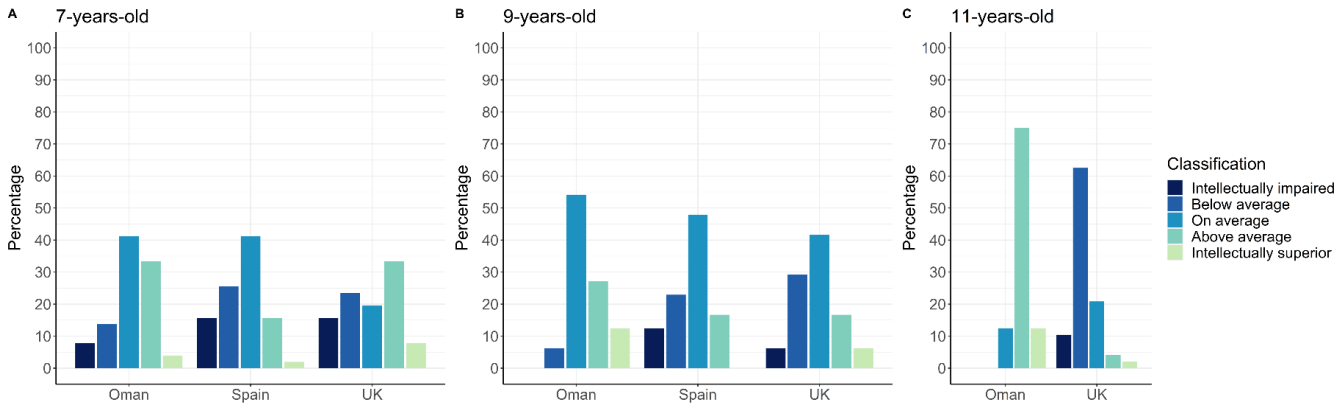

Figure 1. *Misclassifications when transforming the Moroccan raw scores into ranges applying the norms from UK, Spain, and Oman. No data published for the 11-year-olds in Spain.*

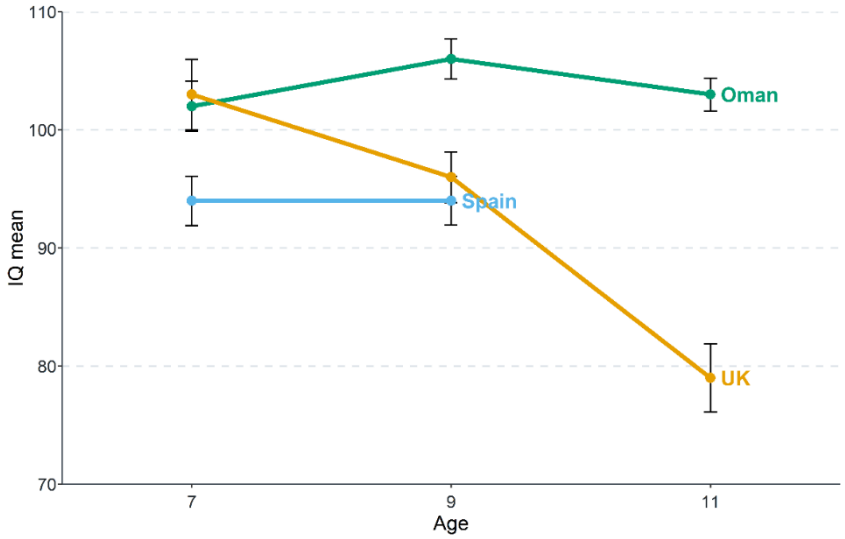

Figure 2. *Moroccan raw scores transformed into IQ applying the norms from the UK, Spain, and Oman. No data published for the 11-year-olds in Spain.*

3.3.4. Applying the norms of Oman

Classification using Omani norms resulted in 13.73% of the 7-year-old sample falling in the "below average" (range IV) and 7.84% in the "intellectually impaired" (range V). The

lowest classification for the 9-year-olds was “below average” (range IV) with 6.25% of children falling in this range. No 11-year-old Moroccan child scored lower than “average” (range IV). Intelligence scores were 102, 106, and 103 points for the 7-, 9-, and 11-year-old Moroccan samples, respectively.

4. Discussion

Both of our hypotheses concerning potential biases in the “cultural fair” CPM when using non-representative norms were supported. The raw scores of Moroccan children were significantly lower than children from the UK (11-year-olds) and Spain (7- and 9-year-olds). This pattern of findings is consistent with performances on other international tests such as the Programme for International Student Assessment (PISA; OECD, 2019), and the Progress in International Reading Literacy Study (PIRLS; Martin et al., 2017), where Moroccan children perform lower than those from the UK and Spain.

Two related cultural factors that could be impacting CPM scores are economics and quality of education (Manly et al., 2002). According to the World Bank (2020), the UK and Spain are high-income countries, whereas Morocco’s economy falls within the low to middle category. A country’s economy has been correlated with IQ scores on western tests (Meisenberg, 2012). Economics can significantly impact quality of education, as countries with the strongest economies tend to have the best educational infrastructure such as highly rated schools, educational expenditures per student, and broadband use, thus would likely provide the best learning opportunities (McPhillips, 2017; OECD, 2016; World Bank, 2020). In addition, educational curriculum could be another contributing factor as pedagogies in Morocco are generally focused on rote-learning (Wagner, 1993;

El-Kogali & Krafft, 2019), while other Western countries, such as the UK or Spain, place more emphasis on active play-based and exploratory learning (Walsh et al., 2010).

An interesting finding when using UK norms, is the lack of significant differences in raw scores for the 7- and 9-year-old cohorts, but significantly lower scores for the 11-year-olds. A possible explanation for this differential pattern is the long- term impact of educational quality on cognitive development. Studies have indicated that years of education are a significant contributor to intelligence development (Cahan & Cohen, 1989; Ritchie & Tucker-Drob, 2018) and quality of education can have long-term impact on cognition (Manly et al., 2002). Thus, it would be plausible that longer periods of exposure to stronger education would result in better scores on intellectual testing over time, as seen in our UK and Moroccan data. The stagnation of Moroccan scores between 9- and 11-year-olds would be supportive of this interpretation. More research is needed to examine the long-term effects of educational quality.

In contrast to UK and Spanish children, Moroccan children significantly outperformed the Omani 9-year-old group. This result is counterintuitive, given the cultural similarities and Oman's stronger economy and educational ranking (United Nations Development Programme, 2020; World Bank, 2020). However, studies have demonstrated that cognitive differences exist between countries that are culturally similar (Buré-Reyes et al., 2013), for example in language, religion, and educational style (El-Kogali & Krafft, 2019; Porcaro, 2011). Our findings would indicate that there are unknown cultural factors aside from educational and economic factors accounting for performances on western tests. One key may be geographic proximity, as geographic distance between countries has been found to be highly correlated with IQ (Gelade, 2008).

Our second hypothesis, IQ scores based on non-representative norms will result in an over-classification of Moroccan children in lower ranges versus the normal curve, was partially supported. We found a large percentage of children falling “below average” (range IV) and classified as “intellectually impaired” (range V) when using the norms from both the UK and Spain. These findings have important implications for the assessment of both Moroccans living in their country and abroad. This test, together with the already limited neuropsychological tools that have been properly adapted and validated in Morocco (Fasfous et al., 2017), can potentially lead to errors of measurement and test interpretation when using non- representative norms. Additionally, considering the proximity of Morocco to Spain and the large number of migrants reaching 707,000 by 2017 (Migration Policy Institute, 2017), there is also a high probability for misclassification of Moroccan children emigrating to Spain who are assessed for clinical or educational reasons.

Clinicians should also be cautious when using the original normative CPM data (UK) to calculate the IQ of the Moroccan children. While the Moroccan children obtained higher raw scores at older ages, the opposite effect was shown when these scores were transformed into a Greenwich IQ with mean IQs decreasing from “below average” at age 7 to “intellectually impaired” at age 11 (almost 2 SDs under the mean). Given similar findings, Bakhiet et al. (2018) concluded that IQ decreases with age in the Arab world. Our findings would suggest that this conclusion was erroneous based upon use of non-representative norms for data interpretation and support Greenfield’s (1997) determination that psychological tests may not cross cultures.

Notwithstanding, this study has some limitations. First, is the small sample size and limited number of age groups, particularly for the Spanish group. A broader age range with larger samples would be important to ensure confidence in our pattern of findings. Second, our cross-sectional design did not control for possible cohort effects which could account for our findings. Third, weaknesses in the test–retest reliability of the Omani norms would limit the validity of our findings. Finally, the demographic data for the study groups were insufficient, which would limit our understanding of group equivalency and group characteristics on test performance.

To increase the accuracy of intellectual assessment when assessing children from different cultures, future studies should develop tests for specific cultures that follow the International Test Commission guidelines for adapting tests (International Test Commission, 2017) and gather norms for sub-cultures or minority groups within the same population (Oliveri & von Davier, 2016). In addition, examining the impact of contextual factors, for example, SES, educational differences, religion, values, behaviors, or economics, on performance on western intelligence tests can both help to elucidate influences on intellectual development and interventions to improve cognition.

CHAPTER 6:

The Misuse of Norms in Intelligence Testing: A Study and Meta-Analysis in Arab Countries

Lozano-Ruiz, A., Fasfous, A. F., & Perez-Garcia, M. (2023). *The Misuse of Norms in Intelligence Testing: A Study and Meta-Analysis in Arab Countries* [Manuscript submitted for publication]

CHAPTER 6:
The Misuse of Norms in Intelligence Testing: A Study and Meta-Analysis in Arab Countries

1. Introduction

The study of human intelligence has long been of interest to researchers in social sciences and psychology (Sternberg & Grigorenko, 1997), as well as other fields such as genetics (Plomin & Von Stumm, 2018), economics and social behavior (Heckman et al., 2006), and anthropology and human evolution (Cosmides et al., 2010). Intelligence plays a crucial role in cognitive functioning and has significant implications for many important life outcomes, including academic and occupational success, social and emotional well-being, and health and longevity (Deary, 2012). Understanding the nature and development of intelligence can provide insights into the cognition and brain, and inform interventions and policies to improve outcomes for individuals and society (Sternberg, 2003).

In psychology, most experimental studies on intelligence have focused on studying racial (e.g., Richard Lynn's work) or temporal differences in intelligence (Flynn, 2007). Research on racial differences in intelligence has often been controversial and has been used to support both sides of the argument about whether or not there are inherent differences in intelligence among different racial groups (Gottfredson, 1997). Some researchers, like Lynn (2006), argue that there are inherent differences in intelligence among racial groups and that these differences are mainly due to genetics. However, Lynn's work has been largely criticized by researchers who point to other factors, such

as cultural and environmental differences (Herrnstein & Murray, 2010), as potential explanations for observed differences in intelligence.

There has been research on the differences in intelligence over time, specifically examining the trend of consistently increasing scores and the possible reasons for this (Flynn, 2007). Several meta-analyses have been published supporting the Flynn Effect (te Nijenhuis & van der Flier, 2013; Pietschnig & Voracek, 2015; Trahan, et al., 2014), indicating that the causes could be due to genetic and environmental factors. These studies have implications for our understanding of the nature of intelligence and how it changes over the lifespan. However, some studies in the last few decades curiously report a negative Flynn Effect, which refers to a decline in intelligence test scores over time (Dutton et al., 2016). The causes of the negative Flynn Effect are not evident in these investigations, although authors relate these to changes to the educational system and dysgenic fertility, according to two studies in Kuwait and Sudan (Dutton et al., 2017a; Dutton et al., 2017b).

However, there is not only theoretical literature claiming to find negative effects on intelligence over time. Bakhiet et al. (2018) report finding an inverse relationship between age and intelligence in the Arab world, which they christen the Simber Effect. In their study, the researchers claimed that intelligence test scores tended to decline with increasing age in the Arab population, a pattern that differed from the generally positive relationship between age and intelligence in normal development (Rosenqvist et al., 2017). Bakhiet et al. (2018) suggest that this may be due to cultural and environmental factors specific to the Arab world, although this finding has not been consistently replicated in other studies.

Both approaches to the study of negative changes in intelligence (temporal and age-related) are alike: both rely on transformed IQ scores that are based on normative data from the UK on the Raven's Progressive Matrices (Raven, 1998). This means that all conclusions and data interpretations are made by using non-representative norms from a different culture. As seen before, the misuse of intelligence norms can lead to impossible IQ estimates and flaws (Ebbesen, 2020) and misclassification of children populations (Lozano-Ruiz et al., 2021).

The aim of this study is twofold: first, to investigate whether the development of intelligence in the Arab world is really negative or, alternatively, positive through a meta-analysis. The second objective, which is linked to the first, is to test whether the transformation from raw scores to IQ using the UK scales behaves differently for different ages. We hypothesize that the curve in the raw scores will be positive when comparing the minimum and maximum ages and that there will also be a positive development when studying the mean raw score at different ages during childhood. However, we hypothesize that this relationship with age will be inverse when transforming all contiguous age groups to IQ, supporting through this contrast that the cause may be linked to the misuse of the norms.

2. Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA-P; Moher et al., 2015) was followed for this study.

2.1. Literature Search

The search was performed on April 2020 (no date limits) on four databases: Scopus, PsycINFO, ScienceDirect, and ProQuest Dissertations and Theses Global (n = 692). An additional search was performed on Google Scholar (n = 261), both in English and Arabic (Figure 1).

For the search, terms related to intelligence, development, and the Raven's Coloured Progressive Matrices test (CPM) were included (Table 1). For instance (PsycInfo): *((intelligence OR iq OR "cognitive abilit*" OR "intellectual abilit*") AND (child* OR development*) AND ("coloured progressive matrices" OR cpm)) AND noft(("coloured progressive matrices" OR "CPM") NOT ("standard progressive matrices" OR "SPM" OR "advanced progressive matrices" OR apm)).*

Once all searches were performed, the results were exported in a bibliographic file for each database. The screening process was performed in two parallel ways according to the language. On one hand, the English results were imported into RStudio to be managed by the *revtools* package, a powerful tool for screening articles (Westgate, 2019). On the other side, Arabic results were imported into Excel to be directly screened by a native Arabic speaker.

After removing duplicates (n = 779), a topic screening was conducted to delete articles not matching our field of study (e.g., artificial or emotional intelligence, developmental disorders, adults, etc.), excluding a total of 365 articles. Then titles, abstracts, and full texts were screened.

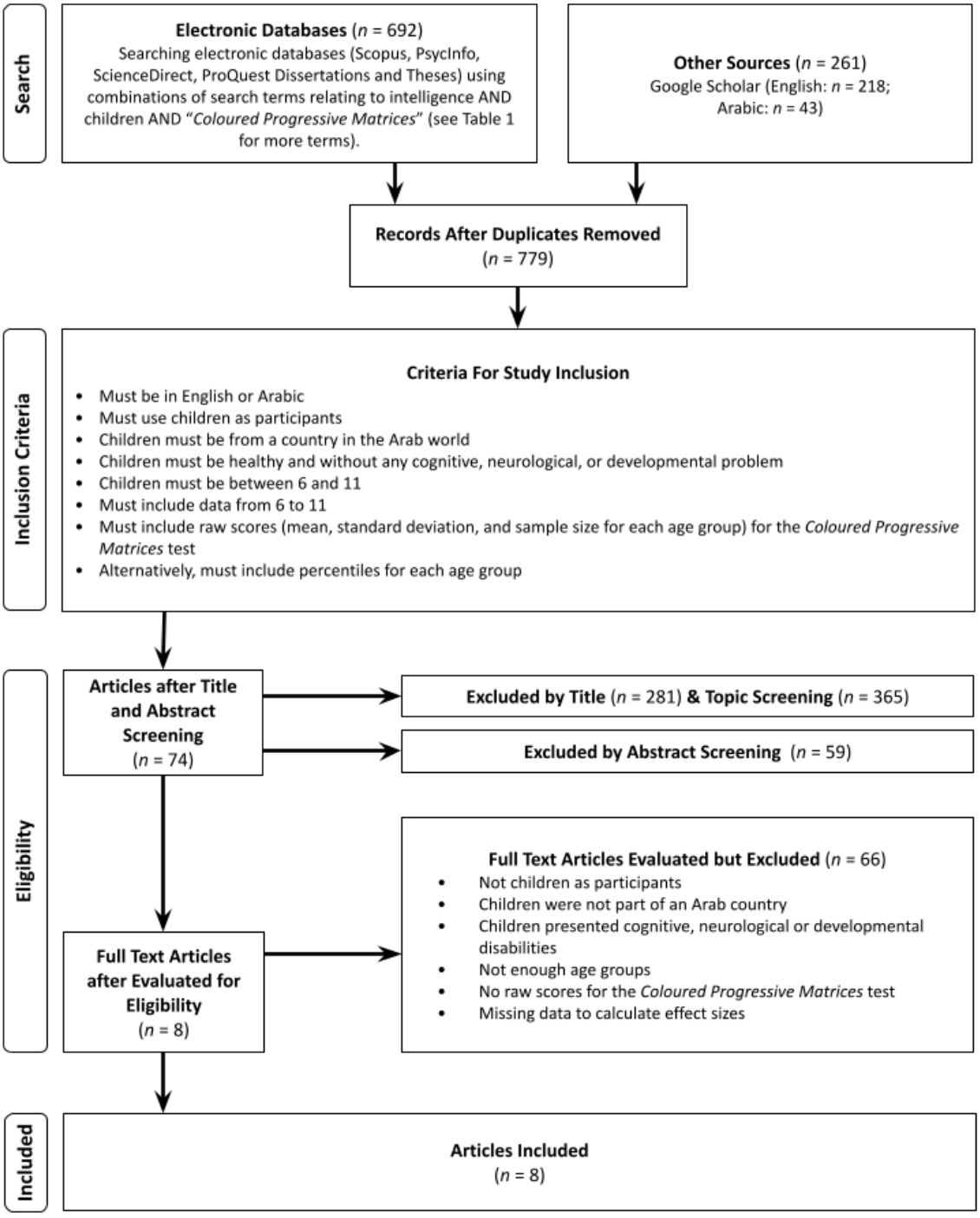

Figure 1. *PRISMA-P flow diagram*

Table 1. *Literature search terms*

Main concepts	Measurement	Population	Exclusions
intelligence	Coloured Progressive Matrices	child*	Standard Progressive Matrices
intellectual	Raven's Coloured Progressive Matrices	non-adult*	SPM
cognitive abilit*	CPM	development	Advanced Progressive Matrices
intellectual abilit*		development*	APM
			elderly

A total of 8 articles meeting the inclusion criteria were then scanned for data extraction. A final database was created containing references, methodological information, and results.

2.2. Selection Criteria

All studies included in this meta-analysis were selected according to the PICOS categories (Moher et al., 2015). See Figure 1 for inclusion criteria.

Only articles reported in English or Arabic languages were included. Both published and not published articles and theses or chapters of books were also considered for inclusion.

Geographical conditions were also applied so that only articles containing data collected in countries from the Arab world were selected (World Bank, 2022): Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco,

Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen.

Finally, only studies containing raw scores for the CPM test's minimum and maximum age group were selected: 6 and 11 (not all articles included 5- and 12-year-olds). These data could be presented in two options:

- Raw scores: Mean, standard deviation, and sample size for each age group.
- Alternatively, percentiles (containing at least the 25th, 50th, and 75th percentiles) and sample size for each age group.

The CPM test was selected because it is the most widely used intelligence test in research and clinical practice for the age range of 6-11 years, and there is a large amount of data available for it from various parts of the world (Raven et al., 1998).

2.3. Data Extraction and Effect Sizes

These data were directly extracted when means, standard deviations, and sample sizes were presented in the documents.

Data were converted into means and standard deviations when only percentiles were found. For the mean estimation, the following formula proposed by Luo et al. (2016) was used:

$$M = 0.7\left(\frac{0.39}{n}\right)\frac{q_1 + q_3}{2} + \left(0.3 - \frac{0.39}{n}\right)m$$

where q_1 is the 25th percentile, q_3 is the 75th percentile, m is the median (50th percentile), and n is the sample size.

For the standard deviation estimations, the following formula was applied (Wan et al., 2014):

$$SD = \frac{q_3 + q_1}{\eta(n)}$$

where *η(n)* is a value included in Wan et al. (2014).

When data was presented separated by gender (boys and girls) or different subgroups within the same age (e.g., 6- and 6.5-years-old), the following equations presented in the Cochrane Handbook (Higgins et al., 2019; Table 7.7.a) were used to pool the sample sizes, means, and standard deviations, respectively:

$$N = N_1 + N_2$$

$$M = \frac{(N_1 M_1) + (N_2 M_2)}{N_1 + N_2}$$

$$SD = \sqrt{\frac{(N_1 - 1)SD_1^2 + (N_2 - 1)SD_2^2 + \frac{N_1 N_2}{N_1 + N_2}(M_1^2 + M_2^2 - 2M_1 M_2)}{N_1 + N_2 - 1}}$$

Once all the mean, standard deviations, and sample sizes were computed for each age groups, Hedges' g effect sizes were calculated using the *esc* package (Lüdecke, 2019).

2.4. Statistical Analyses

2.4.1. Meta-Analysis

A random effect meta-analysis was conducted to study the overall effect size of the age differences in intelligence. Egger's regression test was conducted, and a funnel plot was generated to study publication bias.

All the analyses were conducted using the *meta* package (Schwarzer et al., 2015) for R software (R Core Team, 2021).

2.4.2. Transformations into IQ

Average raw scores for each age group from 6 to 11 were transformed into IQ using the UK norms from Raven's CPM (Raven et al., 1998).

Finally, both variables were rescaled to the same range (0 to 1) to be graphically interpretable.

3. Results

The random-effects meta-analysis showed an overall effect size of g = 1.48, 95% CI [1.124; 1.836], $p < .001$, indicating a very large positive effect (Cohen, 1988).

However, between-study heterogeneity was extremely high: $Q_{(8)} = 190.540$, $p < .001$; $I^2 = 94.82\%$, $\tau^2 = .242$, 95% CI [.095; 1.024]. Overall and specific effect sizes were plotted in a forest plot (Figure 2).

Finally, we conducted Egger's regression test for funnel plot asymmetry (Figure 3), finding no publication bias: $z = -.253$, $p = .800$.

3.1. Meta-Analysis

3.2. Transformations into IQ

Table 2 shows the raw scores mean average and the IQ of these scores transformed using the UK norms for all the included countries merged.

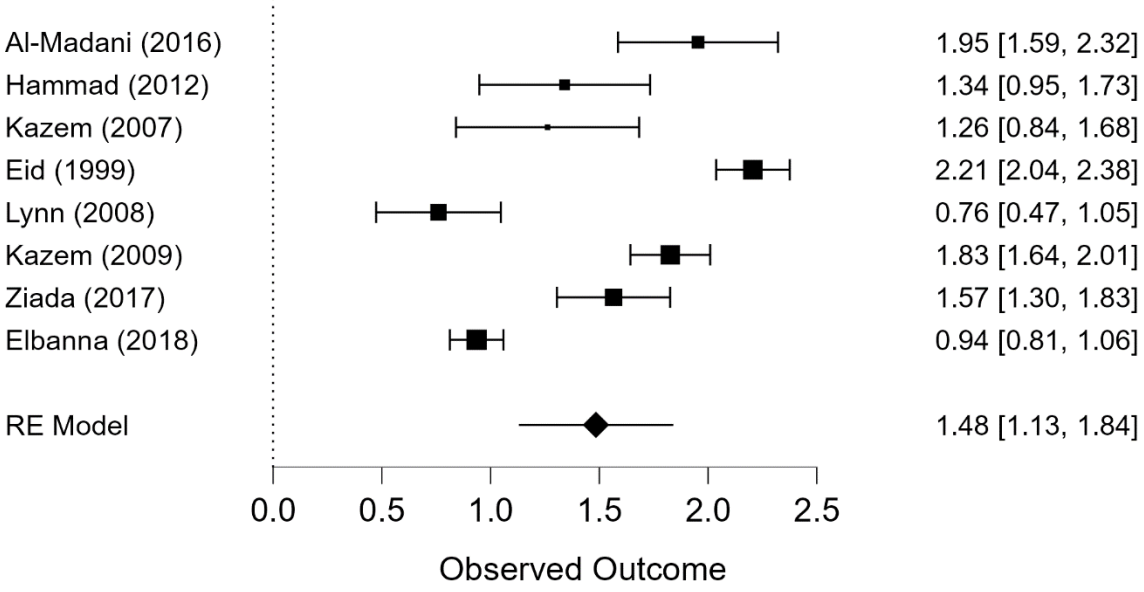

Figure 2. *Forest plot of 6- to 11-years-old differences*

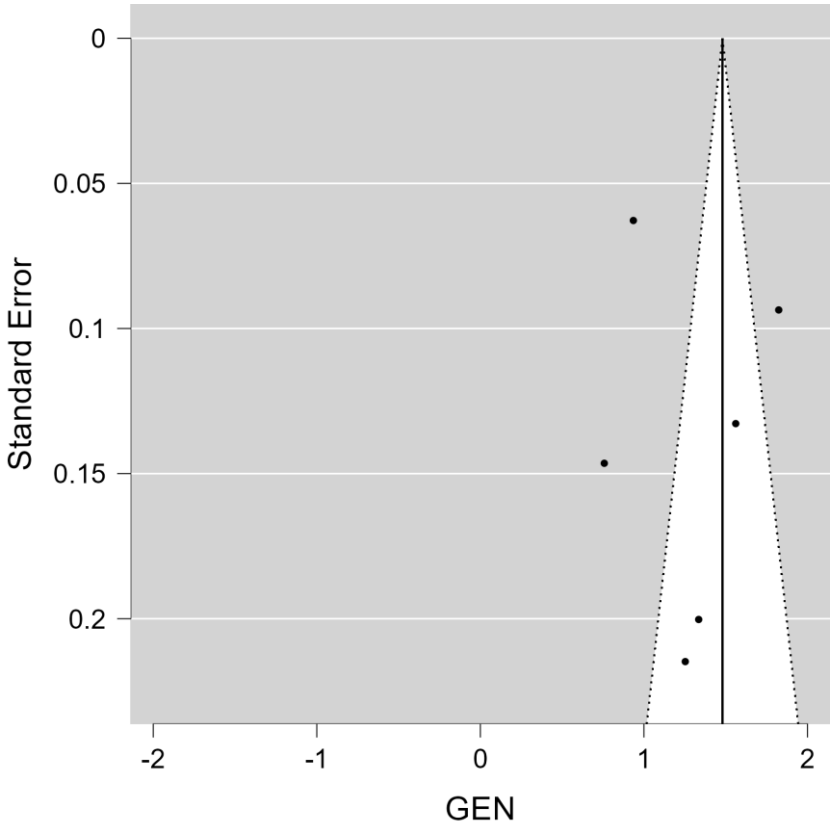

Figure 3. *Funnel plot of 6- to 11-years-old differences*

Table 2. *Raw scores and transformed IQ scores using UK norms for each age group*

	Age group					
	6	**7**	**8**	**9**	**10**	**11**
Raw scores	17.22	18.84	20.46	22.20	23.95	24.58
British IQ	101	96	91	84	83	62

As can be seen in Figure 4, raw scores increased with age, while IQ lowered on average as age increased. The decrease in IQ means has its crossover point at age 9, with its lowest value in 11 years (as previously shown in Table 2).

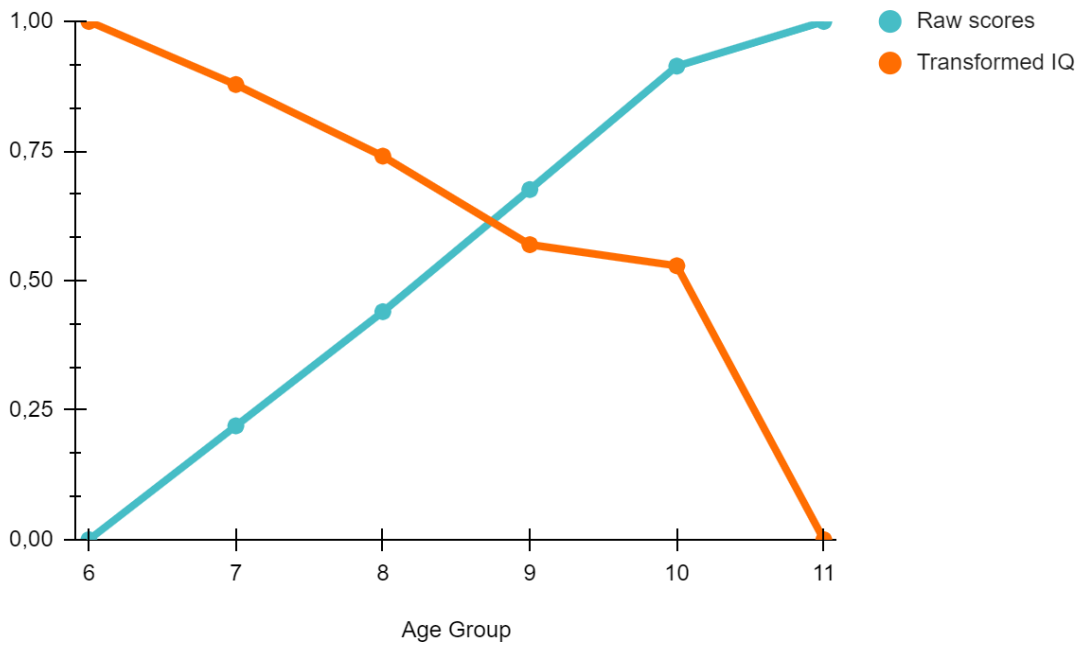

Figure 4. *Curves for raw scores and transformed IQ scores using rescaled variables (.00-1.00)*

4. Discussion

The present study aimed to examine the relationship between age and cognitive ability in children in the Arab world. Our meta-analysis indicated a positive relationship between these variables. However, we obtained the opposite results when we transformed the raw scores of 6- to 11-year-old children to IQ using non-representative norms. This finding supports our hypothesis that inappropriate norms can lead to an inaccurate and biased cognitive ability assessment.

The meta-analysis showed a very large, significant effect size, thus demonstrating a positive development in the CPM test in these countries. Although these are independent cohort data, one would expect intelligence scores, as with any other function, to differ across age groups during childhood. This development is "especially rapid before age 9 or 10 for most neurocognitive functions" (Rosenqvist et al., 2017), so the importance of finding this data behavior is crucial for healthy, normal development. Additionally, there is evidence that interventions aimed at improving cognitive ability in infancy can have long-term benefits (Grantham-McGregor et al., 2007). Therefore, understanding the relationship between age and cognitive ability in infancy is essential for identifying potential areas for intervention and for optimizing cognitive development in early life in different cultural contexts.

Our second objective was to investigate whether there is a difference between the relationship between age and mean raw scores, or age and scores transformed into IQ. We found that while raw intelligence scores linearly increased for each age group, as expected based on the results of our meta-analysis, the British IQ scores were inversely related to age. This suggests that when applying non-representative norms, children are

perceived to become less intelligent as they grow, an alleged phenomenon referred to as the Simber Effect by Bakhiet et al. (2018).

However, using non-representative norms, which are based on Western percentiles and should not "cross cultures" (Greenfield, 1997), is inappropriate for transforming normative raw data into IQ. This may lead to misclassification (Lozano-Ruiz et al., 2021), can be influenced by sample bias (van de Vijver & Tanzer, 2004), can be seen as a poor measure of cognitive ability (Hampshire et al., 2012), and finally, can lead to scientific racism (Ebbesen, 2020).

Furthermore, the decrease in IQ scores was particularly pronounced in the older group, with a mean IQ of 62 (more than 2 standard deviations below the mean), which according to Raven, is considered intellectually impaired. The contrast with the 6-year-old group that is actually at a normal IQ (i.e., around 100), even using non-representative scales, makes it clear that what happens in the first case is not reasonable. These low scores are similar to those of Ebbesen (2020) and our study, in which we attempted to make the same transformations with another Arab country, Morocco (Lozano-Ruiz et al., 2021). One possible explanation for the more significant decrease at older ages could be the more prolonged exposure of children to their cultural and educational context, which may impact their development (Manly et al., 2002). In this way, nonverbal intelligence tests may be more affected by the influence of culture at older ages. For instance, the educational system or learning styles, as well as the quality of education (Fernandez, 2022), can cause cross-cultural differences (Köster et al., 2020).

Finally, we found high between-study heterogeneity in our meta-analysis. While the absence of publication bias suggests that this is not the cause of the variability (Egger et

al., 1997), other potential reasons exist for this variation. For example, the lack of control over other influencing variables in the included studies may have contributed to the heterogeneity (van Hemert, 2011). Cultural variables, such as education, or other variables, such as socioeconomic status, may vary across different cultural contexts and could have a moderating effect on cognitive ability development. Therefore, it is important to consider cultural covariates in cross-cultural meta-analyses to control for their influence on effect sizes through subgroup meta-analysis (categorical variables) or meta-regression (continuous independent variables).

This study has several limitations that should be noted. Firstly, many studies included in the meta-analysis have significant methodological issues, such as a lack of reported psychometric values or a lack of evidence of cultural adaptation. Some studies report reliability and internal consistency, but none address validity. This lack of basic information makes it difficult to control for cross-cultural variability and limits the generalizability of the findings. Secondly, the high heterogeneity in the items included in the studies also hinders the ability to control for cultural differences. Despite these limitations, the main aim of this study was to examine the directionality of intelligence development and cultural differences among populations with relatively close cultural distance (i.e., the Arab world).

Future research should prioritize using culturally adapted and validated norms to ensure the accuracy and fairness of cognitive assessments in different cultural contexts (e.g., following the ITC guidelines, 2017). However, it is also essential to consider new psychometric perspectives beyond culture-specific norms (Fernandez & Abe, 2018). In addition, meta-research methods such as those that examine measurement errors,

heterogeneity (such as this study), or p-hacking (e.g., p-curves analyses) could be valuable in assessing the quality of published findings and the validity of evidence. These efforts will help to combat scientific racism and cultural biases in research, as well as to improve the psychological and neuropsychological assessment of developing children in both educational and clinical settings.

PART III:

GENERAL DISCUSSION, CONCLUDING REMARKS, AND FUTURE RECOMMENDATIONS

CHAPTER 7:

General Discussion

CHAPTER 7:
General Discussion

The main aim of this thesis was to investigate the impact of culture on child development in Arab children. To accomplish this goal, we carried out a series of studies that employed a range of approaches and new methodologies in the field of child neuropsychology. Our research aimed to shed light on the complex relationship between culture and child development through three studies: a review of the accumulated literature in cross-cultural neuropsychology, an empirical study on new cross-cultural comparisons in intelligence assessment and the consequences of using non-representative norms, and a meta-analysis of intellectual development in the Arab world.

Our findings revealed an excessive emphasis on American culture and English-Speaking populations. Also, children's research was three times less frequent than that of adults, thus showing little interest in neurodevelopment from a cultural perspective. Regarding the main topics of study within the field, we identified 25 key areas of focus, the most prominent being neuropsychological assessment, methodological and training issues, and dementia as the most commonly studied clinical issue. Our results are similar to Arnett's (2016) and Thalmayer et al. (2021), who found that most psychology papers focus on American culture, and those by Chiao (2009), who showed the predominance of WEIRD populations in neuroscience studies. However, the fact that this is happening within the field of cross-cultural neuropsychology, which aims precisely to study culture, is counterproductive and alarming. New investigations in unstudied populations,

especially non-Westerns, as well as children, are needed to provide more information and a better understanding of the role of culture in cognition and the brain.

Building on these findings, we aimed to study how culture affects nonverbal intelligence tests. Between-subject comparisons showed normal development in Moroccan children (second study) and Arab children (third study), finding higher scores as children get older. However, when non-representative norms were applied, many healthy children were wrongly classified as intellectually impaired or below average, with the misclassification rate increasing with age. Similarly, IQ scores decreased when UK norms were applied, being lower at older ages. These results have two major reasons for comment: that the CPM is not a "culture-free" test, and that culture may have a greater impact at older ages, and thus on the probability of obtaining biased IQ values.

It is important to consider that nonverbal intelligence tests may behave differently and may even be misunderstood across cultures (Fernandez & Abe, 2018). As seen previously, familiarity and experience with psychological tests can be different across populations; therefore, prior experience and even the skills needed to solve the tests may differ between Western and non-Western cultures (Fasfous et al., 2013b). In our second study, we applied three different norms to our sample, finding more misclassifications when applying the British ones than those from Spain and Oman, another Arab country. These results are consistent with the third study, where the same UK norms were applied to the Arab countries. The Arab population likely differs from the British population in terms of familiarity with testing or even in the quality of education (Fernandez, 2022). Either way, and as Greenfield (1997) warned decades ago,

these results demonstrate that Western tests should not cross cultures, even if they are nonverbal.

Finally, and linked to the previous findings, our results demonstrate that there may be differences in intelligence between cultures regardless of cultural distance. The raw scores of Moroccan children differed from published normative data in the UK, Spain, and Oman at some ages, although higher in the 11-year-old group. Similarly, our meta-analysis showed high heterogeneity between Arab countries. This may be one of the reasons why when norms from other countries are applied to these raw scores, misinterpretations occur. For instance, using UK scales caused Moroccan children to have a very low IQ at age 11, and the IQ of children in the Arab countries to drop increasingly from age 6 to 11, the latter being below 2 standard deviations. It may be possible that, as children grow in age and are exposed to their culture, they become more influenced by cultural and educational factors, such as the educational system (Köster et al., 2020; Manly et al., 2002). This may make the differences, and thus the likelihood of finding biased IQ, increase with age.

Overall, these findings contribute to our understanding of the influence of culture on cognitive development and have several implications for theories and practices in cross-cultural neuropsychology.

1. Theoretical Implications

This doctoral thesis has several implications for research on cross-cultural neuropsychology. Our first findings highlight the low representation of several countries, cultures, and languages worldwide, many of which have never been studied.

This underrepresentation may also potentially perpetuate ethnocentrism and biased outcomes by creating new biased research in Psychology (Teo & Febbraro, 2003). Within cross-cultural neuropsychology, the problem is even more significant, as the main objective is precisely to understand the role of culture in cognition in different contexts. Therefore, future research in cross-cultural neuropsychology must strive for more excellent representation and inclusion of diverse cultural groups to reduce the risk of ethnocentrism and increase the generalizability of findings.

Additionally, research focused on intelligence study has significant flaws due to the misuse of IQ to carry out cultural comparisons with the consequent biased deductions. As it has been already seen, IQ scores can be an inaccurate measure of intelligence (Ebbesen, 2020), and the use of these is a perfect excuse that can give rise to scientific racism in our field and other related fields where intelligence is the object of study (Belhir, 1994). As seen in our second and third studies, these biases can particularly affect non-Western cultures such as the Arab world.

These bad practices in research may be linked to the misconception of “culture-free” tests. As Greenfield (1998) stated, nonverbal intelligence tests can also be based on cultural constructs, so Western tests should not be applied to other cultures. Our results with the Raven’s Coloured Progressive Matrices are consistent with this affirmation, showing that cultural distance can also increase cross-culture differences. Also, the lack of psychometric properties, especially validity, impacts these measurement biases (van de Vijver & Tanzer, 2004). As tests that are not adequately validated may not accurately measure the construct of interest, most research on this topic could not correctly measure the concept of intelligence.

Finally, our results in Moroccan children and other Arab countries follow a similar pattern previously explained: biases are lower in low age groups, while differences and biases in IQ start to become noticeable from 9-10 years old. Studies such as Boivin & Giordani (2009) have also shown the presence of developmental patterns in clinical populations of African children. These authors detail these findings as evidence for the "brain/behavior omnibus model," giving importance to a universal model that benefits the understanding of cognitive development and cultural influence in cross-cultural neuropsychology. This omnibus, based on the cross-level dynamic biocultural coconstructivism proposed by Li (2003), could be studied from other cultures and both healthy and pathological populations. These findings will then be extended to the lifespan and contribute to the advancement and development of the theoretical framework of cross-cultural neuropsychology.

2. Practical Implications

2.1. Clinical Implications

Clinicians must consider tests' cultural applicability and norms when interpreting test results. Our investigations on the use of non-representative norms led to the misclassification of Moroccan children's intelligence scores, highlighting the potential for cultural bias in test results. Misclassifications in intelligence can be the perfect trigger for significant problems in clinical practice, such as a diagnosis of intellectual disability. The DSM-IV (APA, 1994) included a score of 2 standard deviations below the population mean in IQ (<65-70) as one of the criteria (criterion A) for the diagnosis of an intellectual disability. The DSM-5 (APA, 2013) improved upon this criterion by specifying the need to use "psychometrically valid, comprehensive, and culturally appropriate tests." The

ICD-11 (WHO, 2019) includes the requirement for an IQ score "two or more standard deviations below the mean," which should be based on "appropriately normed, individually administered standardized tests" as a criterion for intellectual disability. However, these general guidelines do not provide sufficient detail on ensuring that tests are culturally appropriate and valid.

Furthermore, it is common for clinicians to rely on norms from other countries (e.g., UK norms) when evaluating immigrants due to a lack of available norms specific to their country of origin. This, combined with deficits in adaptive functioning (as defined by criterion B), may contribute to misdiagnosis. It is important to consider the possibility that maladaptive behaviors and functioning observed in immigrant populations may be the result of the acculturation process (Aronowitz, 1984; Berry, 2007) rather than a disorder, and thus should be taken into account when conducting a neuropsychological evaluation to avoid making hasty conclusions.

Another clinical implication specific to Spain is the application of assessment tools to immigrant populations from Morocco, the majority of immigrants in Spain (Migration Policy Institute, 2022). Our results showed that using UK and Spanish CPM test norms can lower IQ scores in Moroccan children with typical development, which could result in a biased diagnosis for children from this country. Similarly, for a child from an Arab country that migrates to another country, there may be difficulties in assigning an IQ score, mainly if the child is closer to 11 compared to 6 years old. Thus, it is necessary to develop and validate assessment tools specifically for use with these populations to ensure that test results are accurate and reliable.

2.2. Educational Implications

There is extensive evidence of the relationship between intelligence and academic achievement (Hattie, 2008). However, cultural differences also exist in academic performance (Herrera et al., 2020; Chen & Stevenson, 1995), making this intelligence-education relationship more complex than many authors think. In this way, assumptions about the influence of intelligence on academic achievement based on non-representative norms can lead to a "domino effect" of biases.

For example, some articles have shown a relationship between intelligence and the Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), or Progress in International Reading Literacy Study (PIRLS) informs (Rindermann, 2007), to some extent that some authors use these scores as synonyms of intelligence in their articles (e.g., Dutton et al., 2016) to reach conclusions about cognitive abilities performance in concrete cultures. In the same way, the Ministry of Education from the United Arab Emirates (UAE) tried to validate the CPM test (Eid, 1999; published in Arabic) and assumed poor performance issues in the UAE children based on inappropriate British IQ transformations.

Therefore, based on the previous clinical implications and our findings, professionals in education need to consider the cultural appropriateness and validity of assessment tools when evaluating children's cognitive abilities to avoid triggering bias or inequality. On the one hand, children may be misclassified and moved to a lower or higher grade based on these biased scores. On the other hand, the labeling of intelligence ranges, especially all those below average, can lead to stereotyping of minority populations. Ensuring fair and culturally accurate assessment of children is crucial for their academic success and

future opportunities. Thus, professionals must consider these issues when selecting and applying intelligence tests.

CHAPTER 8:

Concluding Remarks and Future Recommendations

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1. Concluding Remarks

Based on the results obtained in this thesis, we can conclude the following remarks:

1. The study of new cultural populations will help better understand the impact of culture on cognition and the brain, as well as its development.
2. More research in non-adult populations is needed to better understand the impact of culture on neurodevelopment.
3. Nonverbal intelligence tests are not “cultural-free.”
4. Nonverbal intelligence tests should be culturally adapted and validated for the target population.
5. Using non-representative norms of nonverbal intelligence tests can lead to misclassifications and biased IQ scores.
6. Biased IQ scores are more probably to occur at older ages.
7. IQ scores can decrease to unreasonable values (even considered "intellectually impaired") around 11 years of age.
8. Intelligence development can differ across cultures, even if they are close (e.g., across Arab countries).

2. Future Recommendations

This doctoral thesis provides new findings on the influence of culture on the cognitive development of children in the Arab world from the field of cross-cultural neuropsychology. The results suggest that more research is needed from this

perspective, as well as new methodologies and study populations to better understand the impact of culture on neurodevelopment.

First, it would be very interesting and important to investigate and compare cultures that have not been studied or received little attention, especially non-Western populations such as the Arab world. Using non-adult populations that have been little studied may yield new information on what neurodevelopmental curves look like in different contexts and, in this way, better understand the role of culture in cognitive development and how to encompass different neurodevelopmental pathologies, or simply how normal development works. This recommendation is not only focused on comparing different cultures but also populations within the same culture or populations with a short cultural distance, such as the aforementioned Arab countries.

Secondly, it is necessary to develop and adapt new neuropsychological assessment tests for those populations where tests are unavailable, or their availability is very limited. To this end, new approaches should be considered that attempt to validate and culturally adapt tests that properly measure the construct as it is perceived by the culture to which the test is to be applied to eliminate cultural biases. For this, it is recommended to always consider some specific guidelines for adaptation, such as the ITC guidelines (2017). Similarly, this would eliminate biases related to biased scores, such as the case of IQ, when using norms from other cultures. Related to this, cross-cultural norm approaches should be considered over culture- or race-specific norms (Fernandez & Abe, 2018).

Moreover, new research studying other cultures should consider the different cultural biases that may influence the sample and the research. For this, researchers could follow

the taxonomy proposed by van de Vijver & Tanzer (2004) to encompass three general types of bias (i.e., construct, method, and item bias) and the recommendations by Fernandez & Abe (2018). These considerations are also very important to consider when adapting and validating new instruments. New work can focus on studying the source of various biases in populations, comparisons, or validations of specific tests. Similarly, making this taxonomy fashionable will allow for a better understanding of how these cultural biases operate, as well as collaborate in improving good practices.

Similarly, we recommend opening a line of research in the field of cross-cultural neuropsychology related to meta-science, which helps to quantify and better understand the publication biases within the field. For instance, meta-analyses can synthesize evidence and better explain the influence of some cultural factors in heterogeneity across populations (van Hemert, 2011). Some exciting examples could be the quality of education, acculturation, or cultural distance. Furthermore, p-hacking research using p-curves analysis can help to clarify whether only significant results are published and whether there is publication bias in specific topics (e.g., whether only studies are published where cross-cultural differences are found in a certain domain such as intelligence). This type of research can be doubly beneficial: on the one hand, to better understand the role of culture and cultural biases, and on the other hand, to consolidate the research framework in the field.

Finally, from practice, it is recommended to always consider the influence of the possible three major biases and how different cultural variables may be affecting them. The use of the ECLECTIC framework proposed by Fujii (2018) can help considerably to improve the effectiveness of neuropsychological assessment in minority populations, considering

8 important factors in clinical practice: "E: education and literacy; C: culture and acculturation; L: language; E: economics; C: communication; T: testing situation: comfort and motivation; I: intelligence conceptualization; and C: the context of immigration." On the other hand, it is recommended to complement this with information on other cultural variables that may influence cognitive performance, such as those explained by Ardila (2007; 2020) and Puente & Agranovich (2013), as well as the specific cultural factors and recommendations explained by Olson & Jacobson (2015) for a proper, culturally pediatric neuropsychological assessment.

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