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A Comparison Between Cognitive Assessment and Neurobiology Technology Assessment of Dyslexia: A Literature Review

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Abstract

Dyslexia is a relatively common learning disability among school-age children, which manifests itself in varying degrees of impairment in reading, spelling, and writing. Because of the impact of dyslexia on the patient, evaluation and diagnosis of the disorder is essential. Recent studies on the assessment of Dyslexia have focused on cognitive assessment and neurobiology technology assessment. In this study, we collected studies on Dyslexia assessment in these two dimensions in the past five years and summarized the strengths and weaknesses of each study from a critical perspective to provide information and experience for future research in this field. Objective: The purpose of this study was to conduct a retrospective study. To explore the differences between the two assessment methods from cognitive assessment and neurobiology technology assessment for Dyslexia in the last five years and the advantages and disadvantages of each. Methods: A comprehensive review of the existing literature was conducted by querying scientific databases (such as Google Scholar, Scopus, and PubMed) using keywords pertinent to the topic under investigation. The selection criteria for the journal articles included only those published between 2018 and 2023, with the exception of seminal works considered classic literature. A meticulous evaluation of the titles, abstracts, and full texts of the selected articles was undertaken prior to their analysis and reporting. Finding: According to the findings, evaluating dyslexia using Neurobiology Technology assessment is a prospective trend. Conclusion: According to the research, cognitive assessment and Neurobiology Technology assessment have their respective strengths and weaknesses in assessing dyslexia. However, with the advancement of Neurobiology Technology, this assessment technique has the potential to provide more direct and accurate diagnoses of dyslexia, making it a promising trend for future development. Recommendation: Future researchers are able to utilize these results as a reference to further study on this issue.

Keywords: Dyslexia, Cognitive Assessment, Neurobiology Technology Assessment, Review Researcher, Future Development

Introduction

Dyslexia is a neurodevelopmental disorder that affects an individual's ability to read, write, and spell words (Snowling & Hulme, 1989). Dyslexia was also known as word blindness when it was first discovered, and individuals with the disorder typically read below the level expected for their age. The prevalence of Dyslexia in school-age children ranges from 5% to 17%. Its specific symptoms usually take the following forms: 1. Difficulty reading and writing words: The child may read words incorrectly because he or she cannot see the letters or the shape of the words. 2. Incorrectly reading and writing words: The child may write or read words incorrectly. 3. Difficulty understanding words: The child may have difficulty understanding texts because he or she cannot read the words or the meaning of the words. 4. Difficulty remembering the spelling of words: The child may have difficulty remembering the spelling of words because he or she is not familiar with the difficulty of remembering the spelling of words. 5. difficulty identifying phonemes and syllables: the child may have difficulty identifying words because of inaudible phonemes and syllables. 6. difficulty learning grammar rules: the child may have difficulty learning grammar rules because of unfamiliarity with them(Snowling et al., 2020). The cause of Dyslexia disorder is not fully understood. Some scholars have revealed in their studies that inadequate gaze, excessive eye beat amplitude, reduced ability to simultaneously identify letter sequences, longer gaze duration, and a longer required speech onset latency have been suggested as causes of dyslexia (Werth, 2019).

Because Dyslexia can cause negative effects such as academic difficulties, low self-esteem, social impairment (Nevill & Forsey, 2022), poor concentration, and slow learning (Gibby-Leversuch et al., 2021), assessment and screening efforts for school-aged children are especially necessary. The current psychological and medical fields identify and assess children with or without Dyslexia in two main ways. The first is the use of cognitive assessment tools, such as The Cognitive Assessment for Dyslexia Patients (CAB-DX), The Dyslexia Screening Test-Junior (DST-J), the Strengths and Difficulties Questionnaire (Bryant et al., 2020), and others. The second type of assessment is the collection of neurobiological information, such as oculomotor tracking, brain waves, and Neuronal Response Signals, to determine whether a child has Dyslexia. The second is to collect neurobiological information such as oculomotor tracking, EEG, and Neuronal Response Signals as an assessment tool to determine whether a child has Dyslexia (Prabha & Bhargavi, 2020). Currently, there are few literature reviews that summarize and compare the advantages and disadvantages of these two types of Dyslexia assessment tools, so this study collected relevant articles in these two fields in the past five years to analyze the accuracy of different assessment tools for Dyslexia patients and the shortcomings of existing studies, and to provide valuable information for future research in the direction of Dyslexia assessment.

Content

The current study of Cognitive assessment of Dyslexia

In the last five years of research on Cognitive assessment of Dyslexia, some researchers have relied on scales or tests developed by other researchers, while others have developed new cognitive assessment tools based on country-specific language systems or for specific research purposes.

Researchers Huang and colleagues developed an assessment tool called the Chinese Reading Ability Test (CRAT) in order to target children with Dyslexia within China. According to the study, the CRAT is based on assessing children's verbal processing and reading abilities and uses Chinese lexical compounding awareness to predict the Chinese character reading and vocabulary abilities of the children being tested. The scale is composed of the phonological awareness subscale, the morphological awareness subscale, the rapid automatized naming subscale, the orthographic awareness subscale, the morphological awareness subscale, the rapid automatized naming subscale, the orthographic awareness subscale, and the reading ability subscale. The study examined both the reliability and validity of the CRAT and concluded that the CRAT has adequate reliability and validity (Huang et al., 2020).

In another Dyslexia assessment for Indian school-age children, considering that Indian students tend to have a multilingual system, researchers Rao and colleagues developed a tool called dyslexia assessment for languages of India - dyslexia assessment battery (DALI-DAB), which was developed using three languages, English, Hindi, and Marathi, to assess the subject children in terms of both literacy tests and mediator skills. The study concluded that the DALI-DAB has good reliability and validity and that it is the first validated scale for the assessment of Dyslexia in bilingual children (Rao et al., 2021).

Similar studies include The Flamingo test, jointly developed by scholars such as Rouweler and colleagues, an assessment tool inspired by the French phonics test, which uses the decoding and reading ability of the student subjects as measurement dimensions in Dyslexia students as well as non-Dyslexia students. The test achieved good discrimination between Dyslexia students and non-Dyslexia students (Rouweler et al., 2020).

Some scholars are more interested in designing a cognitive assessment model for assessing Dyslexia to identify and differentiate children with Dyslexia than in developing a new test to assess Dyslexia. Scholars María-José and colleagues, in order to assess and identify children with Dyslexia more carefully and to overcome the differences in diagnostic criteria for Dyslexia among psychologists from different countries (González-Valenzuela et al., 2016; Machek & Nelson, 2007; Ahmadi et al., 2018; Khairi et al., 2022), a new action protocol was developed for use by teachers or educators in teaching. The model consists of four stages: Assessment of instruction, Multilevel assessment of student performance, Specific student assessment, and Cognitive-linguistic measures. The model uses a number of tests and scales such as vocabulary tests, reading fluency tests, cognitive scales, etc., and also requires parents and teachers to participate in multiple structured interviews for the assessment (González-Valenzuela, 2020).

On the other hand, the use of cognitive assessment tools that have been developed by other researchers is also common in the field in recent years for the assessment of Dyslexia. For example, Helland and colleagues used the RI-5, The Teacher Reporting Attitude Scale (TRAS,) and The Children's Communication Checklist-2 (CCC-2) scales to assess Dyslexia in school-aged children aged 5-15 years. The validity of these scales as an assessment of Dyslexia has been demonstrated in studies (Helland et al., 2021). However, to the extent that these developed assessment tools for Dyslexia are used, the more common ones are the Strengths and Difficulties Questionnaire (SDQ) and the Woodcock-Johnson Tests of Cognitive Abilities. Abilities.

The Strengths and Difficulties Questionnaire (SDQ) is a brief emotional and behavioral screening questionnaire for children and adolescents. The instrument captures the perspectives of children and young people, their parents, and teachers (Goodman, 2001).

Bryant and colleagues used the SDQ scale to assess and measure 389 children in a study that showed that the SDQ scale was effective in assessing not only Dyslexia, but also in determining whether children had other psychological problems such as Anxiety Disorder, Depression, and other psychological problems (Bryant et al., 2020). In a study of the impact of the COVID-19 pandemic on children with Dyslexia in Spain, Soriano-Ferrer and colleagues used the SDQ scale to measure children with diagnosed Dyslexia and found that during isolation, children with dyslexia had increased levels of depressive and anxiety symptoms and parents perceived their children to have more emotional symptoms, ADHD, and behavioral problems. Children and adolescents with dyslexia also exhibited less reading activity and less motivation to read during isolation (Soriano-Ferrer et al., 2021). The use of the SDQ scale in this study demonstrates that this assessment tool can be used in the area of ongoing monitoring of emotional problems and reading motivation in children with Dyslexia, in addition to identifying children with Dyslexia. In a further surprising finding, researcher Ayar and colleagues used the SDQ scale in a study of 278 school-aged children with specific learning disabilities (SLD), and the results showed that the SDQ scale was able to accurately determine whether the children had SLD (Ayar et al., 2022). According to the DSM-5 criteria (American Psychiatric Association Division of Research, 2013), SLD includes not only Dyslexia, but also dysgraphia, dyscalculia, and visual This means that the SDQ scale is also accurate in determining other types of specific learning disabilities.

The Woodcock-Johnson Tests of Cognitive Abilities is a valid and reliable instrument for assessing cognitive ability and achievement in children and adults, first introduced in 1977 by Richard Woodcock and Mary E. Bonner Johnson (Woodcock, 1997). In this study, the Woodcock-Johnson IV (WJIV) scale was used to assess children's Reading Comprehension and Language Comprehension as one of the criteria for determining whether a child had Dyslexia, in a study conducted by Sleeman and colleagues on 209 local New Zealand children (Sleeman et al., 2022). Raman and colleagues in order to study the assessment of Dyslexia in children in a multilingual environment, 46 native Indian children aged 8-13 years were selected to participate in the relevant test and Woodcock-Johnsonn III Tests of Academic Achievement were used as an instrument to assess SLD (including Dyslexia) and the results of the study showed the reliability of the scale in determining SLD(Raman et al., 2020). Similarly, Abu-Hamour and colleagues conducted a study on the assessment of Dyslexia in 111 children in Jordan, and Lisa A. Gabel conducted an assessment of Dyslexia in 163 children in the United States using the Woodcock-Johnson Tests of Cognitive Abilities (Abu-Hamour & Al Hmouz, 2020; Gabel et al., 2021, Yaghoobi & Motevalli, 2020).

The current study of neurobiology technology assessment of Dyslexia

Brain imaging has broadened the understanding of the structural and functional properties of neuronal networks in children with developmental disabilities, which has also found technical support from neurobiology for the assessment of conditions such as Dyslexia (Scammacca et al., 2015). Liebig and colleagues used brain imaging to monitor children with Dyslexia versus control normal children and found that children with Dyslexia showed greater differences in auditory brainstem responses to language (Liebig et al., 2020). In a study by Latifoğlu and colleagues, the electrooculography (EOG) method was used to assess children with Dyslexia. specifically, the researchers used the EOG signal to detect and classify eye retractions and skipping lines during reading in children with Dyslexia and healthy children. The study showed that children with Dyslexia made more backward movements while reading text than healthy individuals (Latifoğlu et al., 2021). It is worth mentioning that scholars such

as Nerušil and colleagues have also done research in recent years on the use of eye tracking to assess the accuracy of Dyslexia. The studies did this by processing the entire eye-tracking recordings in time or frequency. The conclusions of the study showed that the eye-tracking system was effective in assessing children with Dyslexia with an accuracy of 95.6% (Nerušil et al., 2021). In a study using eye-movement data to assess Dyslexia, Raatikainen and colleagues also used machine learning in an attempt to allow the machine to autonomously determine whether a child has Dyslexia, with an accuracy of 84.8% (Raatikainen et al., 2021).

Discussion

Cognitive assessment and neurobiology technology assessment has been chosen by scholars in different fields or with different research interests as the two types of methods used in Dyslexia assessment studies in the last five years. One question that cannot be avoided is what are the advantages and disadvantages of each of these methods in assessing Dyslexia?

Based on the above summary of studies conducted over a 5-year period, it was found that cognitive assessment is based on the presence or absence of symptoms of Dyslexia. Specifically, whether the child has significant errors and difficulties in reading and writing words, understanding words, and remembering words. These Dyslexia assessments, questionnaires, or scales rely on the child's understanding and application of words (Erbeli et al., 2022). This also confirms why some studies target children in bilingual settings (Rao et al., 2021). In comparing most studies that use newly created scales or use existing scales as assessment tools, the main difference between the two can be found in how the reliability and validity of the assessment tools are ensured. The advantage of newly developed scales is that they may be more relevant to children in a particular culture or language system, but they may not have been tested over time and their reliability and validity cannot be guaranteed to the same extent as scales that have been implemented for many years. The reliability and validity of choosing assessment instruments such as the SDQ and Woodcock-Johnson Tests of Cognitive Abilities, which have been developed over many years and are widely implemented in the field of assessing Dyslexia, is even more assured. Similarly, the implementation of scales such as the SDQ and Woodcock-Johnson Tests of Cognitive Abilities relies on certain language systems (Hu et al., 2010). The use of these scales may be less appropriate when dealing with children growing up in a multilingual or non-dominant language environment. On the other hand, the use of the above scales has the advantage of being able to determine whether a child has Dyslexia relatively quickly with a certain degree of accuracy. On the contrary, the implementation in the model developed by María-José, mentioned above, for judging children's Dyslexia is more complex, it is not or rarely limited by the language system currently acquired by the child, the assessment process is discreet, but the period is too long compared to the use of the scale (González-Valenzuela, 2020). It is also important to mention that all of the above instruments that rely on scales or questionnaires as tools to assess Dyslexia make certain requirements regarding the age of the child being tested, that is, the child must be able to use a certain amount of language and understand the meaning of the questions on the scale or questionnaire before being able to participate in the assessment.

The use of neurobiology technology to assess Dyslexia, however, has the advantage of being easier to judge on a scale, and the bioinformatics can break through the linguistic limitations, and the bioinformatics does not depend on the child's understanding of the test questions to detect the child's risk of Dyslexia before the cognitive test (Carrasco & Carrasco, 2022). In the field of biological neurology, current research on Dyslexia has evolved from

focusing on the neocortex of the brain and showing changes in the degree of asymmetry in the temporal plane at the structural level to finding abnormal white matter integrity along the left arcuate fasciculus (Guadalupe et al., 2015, Zhao et al., 2016; Bahrami et al., 2021; Vellasamy et al., 2022; Shirehjini et al., 2023). However, within the field of neurobiology, there is no consensus on which neurobiological signals can accurately predict and determine Dyslexia (Norton et al., 2015). This means that currently, it is not possible to assess Dyslexia without controversy by relying on neurobiological techniques alone.

Combining the advantages and disadvantages of cognitive assessment and neurobiology technology assessment in the assessment of Dyslexia, this study proposes the use of a scale that ensures reliability and validity combined with relevant neurobiological information as an aid to determine whether a child has Dyslexia. Dyslexia is a tool to assist in determining whether a child has Dyslexia. This will ensure the accuracy of the assessment tool in the current field of application while minimizing the time required for the assessment. It is also worth mentioning the use of machine learning techniques in the above-mentioned study by Peter Raatikainen on the assessment of Dyslexia, which to some extent indicates that mechanical or artificial intelligence may replace the traditional model of human assessment in the future, helping school-aged children to be assessed more accurately and effectively. Finally, our study believes that the development of neurobiology technology assessment may replace cognitive assessment as the assessment tool for Dyslexia in the future.

Conclusion

The purpose of the current study is to provide a review of the previous studies conducted to compare cognitive assessment and neurobiology technology assessment of Dyslexia. The results showed that Dyslexia, as a learning disability with serious effects on school-aged children, has received increasing attention from scholars and experts in psychology, behavior, and neurobiology, and research on Dyslexia has gradually crossed the boundaries between these disciplines. It is also important to mention that all of the above instruments that rely on scales or questionnaires as tools to assess Dyslexia make certain requirements regarding the age of the child being tested, that is, the child must be able to use a certain amount of language and understand the meaning of the questions on the scale or questionnaire before being able to participate in the assessment. The use of neurobiology technology to assess Dyslexia, however, has the advantage of being easier to judge on a scale, and the bioinformatics can break through the linguistic limitations, and the bioinformatics does not depend on the child's understanding of the test questions to detect the child's risk of Dyslexia before the cognitive test. It is also worth mentioning the use of machine learning techniques in the assessment of Dyslexia, which to some extent indicates that mechanical or artificial intelligence may replace the traditional model of human assessment in the future, helping school-aged children to be assessed more accurately and effectively. Finally, our study believes that the development of neurobiology technology assessment may replace cognitive assessment as the assessment tool for Dyslexia in the future. In this study, in order to identify the progress of research on Dyslexia assessment in the past five years, we divided the above studies into two dimensions: cognitive assessment and neurobiology technology assessment, and critically analyzed the strengths and weaknesses of each study. We hope to provide useful experience for subsequent studies.

Recommendation

Our study makes an important theoretical contribution to learning disability and Dyslexia in which the results help in articulating the underlying role of cognitive assessment and neurobiology technology assessment in the diagnosis of Dyslexia. We make a theoretical contribution by explaining relevant studies on cognitive and neurobiology technology assessment of Dyslexia, to improve the existing knowledge among practitioners and researchers who are interested to work on children with Dyslexia. In doing so, it expands the previous studies that have been based on correlational and experimental studies on Dyslexia assessment to highlight the application of cognitive and neurobiology technology assessment. This study would assist child psychologists, teachers, researchers, and practitioners in focusing their educational and therapeutic efforts and investments better. This is particularly significant since existing literature is almost silent on the investigation of essential knowledge among children with Dyslexia.

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Conflicts of Interest

There were no conflicts of interest between the authors.

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