Learning Disabilities of Chinese Students

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Children with learning disabilities were screened mainly through three ways: the ability–achievement discrepancy approach, Response to Intervention (RTI) and cognitive and neuropsychological assessment of Processing Strengths and Weaknesses (PSW).

Keywords: CHC theory ; Chinese ; dyslexia ; mathematics learning disabilities

1. Introduction

In previous studies, children with learning disabilities were screened mainly through three ways: the ability–achievement discrepancy approach, Response to Intervention (RTI) and cognitive and neuropsychological assessment of Processing Strengths and Weaknesses (PSW). However, a large number of subsequent studies believed that the ability–achievement discrepancy approach was inefficient to some extent [1], and the RTI was only a preventive method for early identification and intervention of students with learning disabilities, rather than a screening method for students with learning disabilities [2]. The PSW has significant advantages in accurately identifying students with special learning disabilities, understanding their learning problems, and providing targeted intervention plans [3]. Cognitive assessment plays a key role in identifying learning difficulties. Among the relevant human intelligence theories, Cattell Horn Carroll (CHC) cognitive ability theory provides a complete evidence-based theoretical framework for understanding the cognitive development of students with special learning disabilities by comprehensively describing human cognitive ability. Under the current research background, the research on the relationship between CHC cognitive ability and academic achievement has gradually increased, and more abundant evidence has proved that cognitive ability has different effects on academic achievement. The broad and narrow abilities of crystallized intelligence (Gc), processing speed (Gs), and working memory (Gsm) are all related to mathematics and language achievements to varying degrees. In addition, auditory processing (Ga) and long-term retrieval (Glr) are also considered to be related to reading. Visual processing (Gv) is not related to reading and mathematics achievements, but may be related to advanced mathematical skills. In addition, more and more researchers pay attention to the role of executive function in the development of students' academic achievements. Some test development has incorporated executive function into their test content, such as the measurement of four abilities, including planning, attention, simultaneous and subsequent processing, and test system in the cognitive evaluation. Some researchers believe that the first two tests are the measurement of students' executive function [4].

2. Concept Definition

In 1962, Kirk defined learning difficulties as students with normal general intelligence but long-term lagging behind, and divided learning difficulties into developmental and academic learning difficulties [5]. Academic learning disabilities mainly refer to the obstacles that students have in school learning. On this basis, Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) divides learning disabilities into reading disabilities and arithmetic disabilities.

Dyslexia is mainly divided into two types: acquired dyslexia and developmental dyslexia. developmental dyslexia mainly refers to that students have no general audio-visual perception disorder or other neurological disorders under the same learning motivation, general intelligence and educational conditions, and their reading level is significantly lower than the normal development level of their peers [6]. DSM-5 diagnosed dyslexia as a reading level lower than the development level corresponding to their age in the standardized test of reading accuracy and understanding. In China, most scholars screen dyslexic students through necessary intelligence tests and reading ability tests. In addition, it is necessary to ensure that students' achievements in Chinese reading are at a normal level of development [7].

Mathematics learning disability is also known as developmental dyscalculia. Its intelligence and reading level are intact [8]. Under normal educational conditions, social background and sensory skills, students are insufficient in extracting mathematical facts and executing computing procedures. At present, there is no clear diagnostic standard for mathematical learning disabilities. Most scholars in China screen students with mathematical learning disabilities through intelligence tests and necessary mathematical ability tests. In addition, students' Chinese achievements must be kept at a normal level of development [9].

The reason for mathematical learning disabilities is that students have obvious defects in specific mathematical cognitive fields, especially in basic number processing. At present, there are four main theoretical assumptions to explain the causes of computational disabilities. One is the hypothesis of number representation defect, in which students have defects mainly in the approximate representation of larger magnitudes and the precise representation of small quantities. Studies have confirmed that compared with students with computing disabilities of the same age, there are obvious defects in the sensitivity of the approximate representation system [10] and the perception of the precise representation system [11]. The second is the number module defect hypothesis, which believes that computational disabled students have defects in the process of representing accurate quantities in the form of quantity sets, and subsequent research has also confirmed that this defect only exists in computational disabled students [12]. The third is the numerosity coding defect hypothesis, which believes that there is a defect in the internal coding system composed of brain neurons for the representation of accurate quantities by students with computational disabilities. Subsequent research confirmed this hypothesis by exploring the characteristics of defects in the number processing process of students with computational disabilities in grades 5 and 6 through sensory number and counting tasks [13]. Finally, there is the hypothesis of quantity access defect [14]. This hypothesis believes that the poor number symbol skills of students with mathematics learning disability cannot support the quantitative meaning in their acquisition of symbols. Some studies [15] conducted research on students in grades 1–4 through psychological number line task and number point task and other research paradigms, and found that the characteristics of mathematical ability defects of students in grades 1–2 in all subjects conform to this hypothesis.

In addition to dyslexia and math disorder, the comorbidity of reading disability and mathematical disability has gradually attracted scholars' attention. Specifically, dyslexia and mathematical disorder occur simultaneously in one individual, which is similar to the concept of mathematical disorder subtype semantic memory disorder [16]. Some studies believe that the main reason for this symbiotic phenomenon may be that these obstacles are affected by the same factor [17]. The diagnosis basis for children with this type of disorder comes from the relevant studies on dyslexia and dyslexia in mathematics, which mainly means that under the conditions of normal intelligence and normal education, students have no neurological and organic injuries, and their reading ability and mathematical ability are significantly behind their peers.

3. Linking Dyslexic to Cognitive Deficits

In 1976, Hellman believed that the development of a series of complex language functions is based on auditory processing ability, which has a great impact on many academic fields of students. Among them, speech processing ability, as a special auditory processing ability, is one of the core defects of dyslexia. The main viewpoint of auditory processing disorder is that the fine processing of sound information by the auditory system over time is an important condition for the development of speech skills and a key factor affecting the development of language ability. At present, the differences in the research on the auditory processing of dyslexic students mainly focus on two aspects: on the one hand, dyslexic students have defects in the ability of fast time processing of auditory signals; for example, Martino found that compared with normal children, dyslexic children have defects in the ability to analyze different sound presentation sequences after extensive research on the time sequence judgment task of the classical experimental paradigm of auditory fast time processing ability of dyslexic children. After changing the interval time of sounds, it was found that the performance of dyslexic students in judging the order of sound presentation improved with the increase of interval time [18]. On the other hand, it is believed that the dyslexic students have the ability to process the non-temporal characteristics of auditory signals, such as frequency and amplitude changes. It is found that the dyslexic students are less sensitive to the changes of sound amplitude and frequency than the normal people. For example, some research used tasks such as speech repetition, frequency discrimination, and auditory fast time judgment to test subjects' auditory processing ability, and found that the formation of differences in speech processing ability between dyslexic subjects and normal subjects was related to non-temporal auditory ability, but not to auditory fast time processing ability [19].

In addition, some studies divided speech processing ability into speech awareness ability, speech coding ability and speech memory ability [20], Among them, phonological awareness is the prerequisite for students' success in reading [21]. It is also found that pronunciation plays a key role in the reading process in the Chinese environment [22]. The root of Chinese dyslexic students lies in their special defect in phonological processing ability [23]. In addition, phonological memory ability is also a key factor affecting students' reading development. It has been found that the capacity of verbal working memory plays a crucial role in the success of reading comprehension [24]. This may be related to the process that the speech processing ability, which is regarded as the basis of reading and decoding skills, requires short-term storage of phonemes in verbal working memory.

In addition, the process of reading comprehension depends on the ability to preserve text information and integrate information in working memory. This relationship also exists in the learning process of complex Chinese environment [25]. The key role of working memory in learning has cross language consistency [26][27].

Executive function plays a key role in reading comprehension, which is composed of three independent and closely related functions: inhibition, updating and shifting [28]. In addition, the central executive system in the working memory model can be regarded as a lower level executive function [29]. According to the existing research [30], students aged 8–11 with good reading comprehension ability and those with poor reading comprehension ability have two updating tasks with an interval of one year. It is found that students with poor reading comprehension ability perform worse, receive more interference from irrelevant information, and students with poor updating ability are more likely to have reading difficulties. Further research shows that this may be due to the failure of inhibition control function, which leads students to retain more irrelevant information; that is to say, the relationship between updating ability and students' reading comprehension is affected to some extent by inhibition control ability. Through the active interference task of 10–11 year old dyslexic children to explore the efficiency of their inhibition control, it was found that dyslexic people with poor comprehension showed specific inhibition task defects [31]. Some studies also found that the mechanism of inhibition control function in supporting reading comprehension is mainly to control irrelevant information through combing the literature [32]. In addition, this research pointed out that cognitive flexibility supports reading comprehension by integrating semantic and phonetic information and flexibly allocating attention to text features and reading strategies. Some studies assessed the relationship between the executive function and reading comprehension of 4–5 Chinese students through the classic Stroop paradigm and the span task, and found that the influence of executive function on the reading comprehension process of Chinese students exceeded the influence of vocabulary knowledge and metalinguistic awareness [33], which to a certain extent reflected the cross language consistency of the influence of executive function on reading comprehension.

In addition, some studies [34] believe that the key processing ability affecting language related achievements is processing speed ability in addition to working memory. However, the research on the relationship between processing speed and students' reading achievements is quite contradictory. Some studies believe that this ability does not play a key role in reading achievement [35], and this view has also been confirmed by research in the Chinese environment [36].

Long term retrieval ability is significantly related to students' reading achievements. The reading process requires students to retrieve key information from the corpus stored in their long-term memory. Some studies [37] found that the definition and measurement methods of retrieval fluency ability and rapid automatic naming ability in long-term retrieval ability almost coincide. The significant correlation between rapid automatic naming and reading [38][39] also confirms the key role of long-term extraction in the reading process. In addition, in the Chinese environment, some studies have also found that children with dyslexia perform poorly in rapid naming [40]. Some studies believe that the reason for this situation is related to the failure of the central executive system of working memory to inhibit irrelevant information during information retrieval [41].

Most Chinese characters are ideographic characters composed of semantic components and transliteration components. This complex composition in terms of vision, pronunciation and semantics puts forward higher requirements for orthography [42]. Visual spatial processing ability plays a key role in the process of Chinese students forming correct orthography knowledge. In the context of the current research on orthographic defects as the core defect of dyslexia, more and more researchers believe that dyslexia arise from deeper research on visual processing cognitive impairment, but the results are divergent. The dominant pathology theory holds that the visual defect of dyslexia is compensated by other defective abilities, which is also proved by neurophysiological research [43].

In addition, crystallized intelligence is related to the accumulation of students' speech and vocabulary knowledge. Some studies have found that crystallized intelligence and students' reading achievements promote each other [44]. In addition, studies on cognitive characteristics of dyslexic children have found that there are defects in their crystal intelligence [45]. Some studies have found that the defects in students' semantic knowledge are the main reasons for their dyslexia after studying some dyslexic students who have no problems in word recognition ability [46].

4. Linking MD to Cognitive Deficits

Executive function is a key factor that affects a series of advanced cognitive skills, including mathematics. It is also a key factor that promotes students' acquisition of mathematical skills. Different components of executive function, such as working memory [47], inhibition control [48] and cognitive flexibility [49], are key factors that affect students' mathematical success. In a word, executive function is closely related to mathematics and dyslexia students in English environment. In the Chinese environment, some studies have found that executive function is significantly related to Chinese students' mathematical achievements [50]. Some studies [51] have measured the executive function of 165 Chinese children aged 5–6 years by the keep track task, the Stroop task and the card sorting task, and found that working memory is the key factor affecting the mathematical achievements of Chinese students. In addition, some studies [52] measured students' inhibition control through color stroop task and found that inhibition control was the key factor affecting students' number concept development. For example, after measuring students' transfer ability, it is found that transfer ability is the key factor affecting students' mathematical achievements. Some studies [53] explored the development of transfer ability of four types of Chinese students (double excellent students, double poor students, students with math learning difficulties, and students with reading disabilities) through Wisconsin card classification task, and found that transfer function is a key factor affecting students' math learning. Cognitive flexibility is based on working memory and inhibition control, and this ability appears only after working memory and inhibition control. The three abilities have different development trajectories. Working memory and inhibition control are the abilities that perform earlier as executive functions, which together form the basis of cognitive flexibility [54].

Students with MD have obvious defects in the central executive system of working memory, verbal working memory and visual spatial working memory. The influence of working memory on mathematics even appears in the simplest calculation process of students [55]. In English environment, students' mathematical achievements are affected by working memory systems in general and special fields. In the Chinese environment, working memory [56] is also a key factor affecting students' mathematical achievements. Because of language specificity, Chinese students' verbal working memory also has a certain impact on their calculation process. For example, verbal working memory has a certain impact on Chinese students' single digit multiplication process [57].

Students with MD in Chinese environment also have the characteristics of slow processing speed [58]. A study [59] found that processing speed is related to students' ability to calculate and solve problems. Higher processing efficiency can increase students' memory storage ability and improve students' computing efficiency to a certain extent. However, some studies believe that the perception, representation and processing speed of information are crucial to the efficiency of working memory [60], which may mean that the influence of processing speed on mathematical achievements may be indirectly carried out through the way of affecting working memory.

Students with learning disabilities in mathematics are accompanied by serious defects in visual spatial addition ability. Some studies believe that students' ability to maintain and operate visual spatial information plays a key role in students' counting [61], computing [62], problem solving [63] and other mathematical abilities. In addition, There are research [64] findings visual reasoning ability is also a key factor affecting students' problem solving through measuring students' mental rotation. In the Chinese environment, some studies have found that [65] visual spatial processing disorders are significantly related to mathematical disorders. Specifically, students with MD lag behind normal children in spatial attention, spatial memory and spatial reasoning [66]. Visual spatial ability in Chinese environment can predict the development of students' mathematical achievements to a certain extent [67].

Long term retrieval ability is also significantly related to mathematical achievement, which has also been found in Chinese environment [68][69]. Children with mathematics learning disabilities are not unable to remember correctly and retrieve facts. There may be three mechanisms that affect students' retrieval ability [70]. One is that the representation of voice, language and voice established in long-term memory of students with mathematics learning disabilities is insufficient, which affects the development of students' counting ability at the initial stage of mathematics learning to a certain extent. The second is that students' ability to restrain irrelevant information entering working memory is insufficient in the process of mathematical fact retrieval. The third is that there are defects in the students' quantity representation system, which includes an approximate number system and Precise number system. It helps students establish digital psychological representation through basic numerical processing. In fact, this may be very important in the students' mathematical learning process, and it is the basis for students to learn basic arithmetic and learn more advanced mathematical knowledge and skills [71]. Generally speaking, the more correct memory representations that students can retrieve, the better their math scores will be. Otherwise, students may have difficulties in mathematical calculation and problem solving [72][73].

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