

Review of Visual Attention Span Characteristics and Intervention in Developmental Dyslexia

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Abstract: Developmental dyslexia is a specific learning disorder with an incidence rate of approximately 5% - 17.5% globally. It is a learning disorder that affects an individual's reading ability and the acquisition of reading-related skills, with core characteristics including difficulties in decoding text, slow reading speed, and limited comprehension. It not only impacts an individual's academic performance but may also have long-term effects on their self-esteem, social skills, and future career development. This article synthesizes multiple kinds of literature to conduct an in-depth analysis of the visual attention span characteristics and influencing factors of individuals with developmental dyslexia and discusses the relevant effects in detail. Research shows that the developmental dyslexia group has a visual attention span deficit, and this deficit is modulated by multiple factors. Meanwhile, two intervention methods, visual attention training tasks and action video games, have been proven to effectively improve the visual attention ability and reading performance of children with dyslexia.

Keywords: Developmental dyslexia, Visual attention span, Intervention methods

1. Introduction

Developmental dyslexia refers to the situation where an individual, with normal intelligence, an appropriate learning environment, and no other neurological or mental disorders, experiences persistent and severe difficulties in learning areas such as reading and spelling and fails to reach a reading level commensurate with their intelligence and age [1]. Early research mainly focused on phonological processing. Multiple studies have shown that Chinese children with developmental dyslexia have deficits in phonological processing, especially in the three dimensions of phonological awareness, verbal short-term memory, and lexical retrieval. By comparing children with prominent reading disabilities (DD group), normal reading ability (CA group), and poor reading level (RL group), it was found that children with reading disabilities performed poorly in these three dimensions. However, in recent years, exploring its causes from the visual processing level has become a hot topic, and the ability to have visual attention spans as the basis of visual processing, has received attention [2]. Therefore, this study synthesizes multiple pieces of literature to systematically analyze the visual attention span characteristics of the developmental dyslexia population, providing a certain reference for subsequent research, and also analyzes two intervention methods, aiming to provide effective intervention strategies and methods for educators and psychotherapists, helping this group improve reading disabilities, enhance reading and learning effectiveness, and promote physical and mental health development.

2. Visual Attention Span Characteristics

2.1. Research Methods and Results

2.1.1. Research Status of Patients with Alphabetic Writing Background

In the context of alphabetic writing, some studies have found that children with developmental dyslexia have visual attention span deficits. Tang Jiuqing et al. analyzed 4,211 subjects. Overall, compared with their normally developing peers, the developmental dyslexia population showed visual attention span deficits, and there was no age modulation effect [3]. Similarly, Liu Jingqiu et al. also reached the same conclusion using the global/partial report task [4].

There are also studies that did not find visual attention span deficits in dyslexia. For example, Hawelka and Wimmer's study found that when the stimulus was a graphic, there was no significant group difference between dyslexic adults and normal readers [5]; Yeari et al.'s research results showed that there was no significant difference in the stimulus recognition sensitivity between Hebrew dyslexic adults and the control group in the whole and partial report tasks [6].

2.1.2. Research Status of Patients with Chinese Background

In the context of Chinese, some studies have shown that Chinese children with reading disabilities have visual attention span deficits. Li Ruiyan et al. adopted a two-factor mixed design of 2 (subject groups: primary school students with developmental dyslexia and primary school students with normal reading ability) $\times$ 2 (Chinese character types: simple and complex) and used the Visual - 1 - back task to measure. They found that Chinese primary school students with developmental dyslexia in the lower age group showed visual attention span deficits in Chinese materials [7]. Liu Hanlong et al. found through horizontal comparison that the deficits were more severe in the higher age stage [8].

However, some studies have also shown that there is no significant difference in the visual attention span tasks between developmental dyslexia and normal readers. For example, Mi Xiaoli used the oral whole or partial report method to test the visual attention span of Chinese children with reading disabilities in grades two to five in primary school. The research results showed that there was no significant difference in the visual attention span test scores between Chinese children with reading disabilities and their peers with normal reading ability [9]. Zhao et al. found that the scores of children with reading disabilities in the middle and lower grades in the visual attention span test were not significantly different from those of children with the normal reading ability of the same age. At the same time, the deficits were obvious in the senior grades. There were some children with a lower proportion of deficits in the middle and lower grades, which is similar to the research results of Liu Hanlong et al [10].

2.2. Influencing Factor Analysis

2.2.1. Age

Some studies have shown that the regulatory effect of age on the level difference of visual attention span is not obvious. That is, both adults and children with developmental dyslexia show significant visual attention span deficits, and there is no significant difference in the severity of the deficits. However, there are also related studies that hold different views. For example, the research results of Liu Hanlong and Zhao et al. show that the visual attention span will become more severe with age [10].

2.2.2. Writing System

Writing is a skill that must be learned later. Lachmann Thomas pointed out that literacy acquisition is affected by multiple cognitive functions and varies with different languages and writing systems. However, most studies on literacy acquisition and developmental dyslexia have focused on the alphabetic writing system, which may lead to inappropriate generalizations of research results in different languages and writing systems [11]. Zhu Nan et al. showed that the writing system has a significant regulatory effect on the level of difference in visual attention span. By comparison, it was found that in the non-alphabetic writing system (especially Chinese), the effect size is lower than that in the alphabetic writing system. The visual attention span deficit of the developmental dyslexia population in the Chinese writing environment is relatively mild [12].

2.2.3. Orthographic Depth

In various orthographic depth contexts, the visual attention span level of patients with developmental dyslexia is significantly lower than that of ordinary readers. Compared with the shallow orthographic language background, the difference in effect size is more prominent in the deep orthographic language background. For example, Awadh et al. compared the visual attention span of Arabic, Spanish, and French adults. The results showed that the orthographic depth of French is deeper, and the results also showed that the visual attention span of French adults is closely related to reading fluency [13].

2.2.4. Task Paradigm

Zhu Nan et al. summarized previous studies and concluded that the task paradigm has a significant regulatory effect on the level difference of visual attention span in individuals with developmental dyslexia. The effect intensity of the all-present-and-report task paradigm is higher than that of the partial-present-and-report task paradigm, and the visual attention span in this paradigm is more restricted by visual short-term memory factors [12].

3. Different Intervention Methods and Effects

3.1. Visual Attention Training Task Intervention

3.1.1. Intervention Method

Valdois and his team developed a series of intervention activities aimed at broadening the visual attention range for an individual with both French and Spanish language disorders, including visual search and other tasks, aiming to strengthen the visual attention skills of the participants to expand their visual attention span [14]. In China, Meng Xiangzhi et al. conducted visual texture discrimination task training and measurement on 18 children with reading disabilities and 18 normal readers of the same age and intelligence [15]. Zhao et al. designed visual training projects such as digital search games [16].

3.1.2. Intervention Effect

The research results of Valdois et al. showed that after training, the word recognition speed and text reading speed of the subject in French reading was significantly accelerated [14]; Meng Xiangzhi et al. found that children with reading disabilities had deficiencies in visual information processing. In the training group specifically for reading disabilities, the reading fluency of children was significantly improved and the effect lasted for two months, indicating that visual perception training

may promote reading fluency [15]. Zhao et al.'s research proved that visual training intervention has a positive effect on improving the visual attention span of children with reading disabilities, which is reflected in the improvement of the accuracy rate and the shortening of the reaction time of the subjects in the 1-back task, and the accuracy of the silent reading of children has been enhanced [16].

3.2. Action Video Game Intervention

3.2.1. Intervention Method

Action video games have the characteristics of multi-target display and high cognitive requirements. Franceschini et al. selected 10 Italian children with reading disabilities and 28 English children with reading disabilities for 12 hours of training [17]. Sara Bertoin et al. selected 18 children with developmental dyslexia to participate in their action video game training study, and each child received 12 individual treatments within two weeks [18]. Domestic researcher Liu Fangfang conducted a 12-hour action video game intervention on 120 Chinese children with reading disabilities [19].

3.2.2. Intervention Effect

Many domestic and foreign studies have confirmed that action video game intervention can effectively expand the visual attention range of children with reading disabilities and have a positive promoting effect on their reading speed and reading efficiency. For example, Franceschini et al.'s research showed that the reading speed of children with reading disabilities after action video game training was significantly improved [17]. Liu Fangfang's research found that the accuracy rate of the intervention group was significantly improved [19]. However, for some studies, such as Sara Bertoin et al.'s study, it was found that some children did not benefit from the game, which may be because the game difficulty was relatively high for some children, resulting in a low benefit level, but this also requires further research to confirm [18].

4. Review

4.1. Research Deficiencies

From the current research progress, the research results obtained by various studies are inconsistent. In terms of visual attention span characteristics, both in the context of alphabetic writing and Chinese, some studies show that children with reading disabilities have visual attention span deficits, while some studies have not found significant differences. This may be due to differences in research methods, experimental materials, or subject groups, but at present, it is not clear how these factors specifically affect the research results, leading to increased uncertainty in the conclusions.

Although the influence of factors such as age, writing system, orthographic depth, and task paradigm on visual attention span has been explored, there may be interactions among these factors, and current research involves relatively little. For example, it is not clear how age, combined with the writing system and orthographic depth, jointly affects visual attention span.

In the intervention research, the sample size is generally small. For example, the Valdois team only conducted research on one individual, and Meng Xiangzhi et al. each had 18 children as research objects, etc., which may affect the universality of the research results. At the same time, for the action video game intervention, although it is generally shown to be effective, the reasons why some children do not benefit have not been deeply explored.

4.2. Outlook

Future research should try to unify research methods, clarify the selection criteria of experimental materials, and standardize the selection range of subject groups to reduce the inconsistency of results caused by differences in research methods and experimental materials and improve the reliability of research conclusions.

Further study the interaction relationships among factors such as age, writing system, orthographic depth, and task paradigm, and construct a more complete theoretical model to more accurately explain the change mechanism of the visual attention span of individuals with developmental dyslexia.

Increase the sample size of intervention research to make the research results more representative. For the situation where some children do not benefit from the action video game intervention, deeply analyze the reasons, optimize the game design or develop personalized intervention programs to improve the effectiveness of the intervention and better help children with developmental dyslexia improve their reading ability.

5. Conclusion

This study synthesizes multiple works of literature to systematically analyze the visual attention span characteristics of the developmental dyslexia population, including the research results and influencing factors in different phonetic backgrounds, such as age, writing system, orthographic depth, and task paradigm. At the same time, it deeply explores two intervention methods, visual attention training tasks and action video games, and their effects. The research results provide a more comprehensive perspective for understanding developmental dyslexia, especially supplementing the previous research mainly focusing on phonological processing from the visual processing level. It also provides effective intervention strategy references for educators and psychotherapists, helping this group improve reading disabilities, enhance reading and learning effectiveness, and promote physical and mental health development.

However, this study has certain deficiencies. In terms of research methods, the results lack integration and are scattered, the results of different writing systems have not been deeply compared, and the relationships of influencing factors have not been systematically presented. The analysis of the limitations of the conclusions is not deep, and the suggestions for future directions are general. For example, the mechanism of the difference in research methods leading to results is not clear, and the steps of unifying methods are not detailed. In the future, in terms of content depth, the research of different writing systems should be deeply compared, the different factors should be analyzed, and at the same time, the influencing factors should be integrated and a model should be constructed to explain the relationships. In terms of critical thinking, when evaluating research results, factors such as sample size should be considered, the differences in controversial methods should be analyzed, and potential problems in intervention research should be explored. For example, in the action video game intervention, the factors why children do not benefit should be analyzed and improvement measures should be proposed to improve the quality of the review.

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