THE EFFECTIVENESS OF PARMIS COGNITIVE REHABILITATION PACKAGE ON IMPROVING ORTHOGRAPHIC KNOWLEDGE IN IRANIAN DYSLEXIC STUDENTS

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ABSTRACT

Background and purpose: Recently, a general implicit sequence learning deficit was proposed as an underlying cause of dyslexia. The aim of this study was to investigate the effect of parmis cognitive rehabilitation on improving orthographic knowledge in dyslexic students. Materials and Methods: The research method was a quasi-experimental pre-test-post-test with a control group. The statistical population consisted of all primary students with dyslexia in Babolsar city in the academic year of 2009-2010, who were referred to the learning disability center. Thirty samples were selected by convenience sampling method and after confirmation of the diagnosis by experts in two experimental and control groups (15 in each group) were randomly assigned. Finally, due to the drop in samples, it was reduced to 11 in the control group and 14 in the experimental group. The experimental group received the parmis cognitive rehabilitation program for 5 sessions and the control group did not receive any intervention. Research instruments included Raven IQ test, orthographic knowledge test and parmis cognitive rehabilitation program. Data were analyzed using univariate analysis of covariance.

Results: The findings showed that parmis cognitive rehabilitation program is effective in improving orthographic knowledge of dyslexic students.

Conclusion: parmis Rehabilitation Program can be used to improve orthographic knowledge in dyslexic students.

Keywords: Orthographic Knowledge, Cognitive Rehabilitation, Dyslexia, Implicit Motor Sequence Learning.

I. INTRODUCTION

One of the metalinguistic skills is orthographic knowledge, which has identified by theories of literacy development that contribute to the acquisition of reading and spelling (Apel, Wilson-Fowler, Brimo, & Perrin, 2012). The term orthography is derived from two Greek roots: orthos means correct and graphein means writing. Orthographic knowledge represents information stored in memory and tells us how spoken language can be presented in written form; through the etymology of the word, knowledge is the correct way to write a language (Apel, 2011). Researchers have explored orthographic knowledge as a potential facilitator in the development of literacy; they found that orthographic knowledge contributed exclusively to the growth of reading (e.g., Apel, 2011; Cunningham, Perry, & Stanovich, 2001). Mental Graphemic Representations (MGRs) and orthographic patterns are both components of orthographic knowledge. MGR knowledge represents memories of specific written words, while orthographic pattern knowledge implies an understanding of the patterns that govern a symbolic system (Apel, 2011). These two components are consistent with how people read and write (e.g., Perry, Ziegler, & Zorzi, 2007). That is, people read and write words, either by accessing previously stored knowledge of the specific words (MGRs) or by using knowledge of orthographic patterns as part of decoding or encoding.
Among the alphabetic orthography, there are degrees of Grapheme-phoneme adaptation, which can have consequences for the mental processes involved in normal and dyslexic individuals. The term “orthographic depth” is used to distinguish orthographies on a continuum ranging from shallow to deep (Baluch, 2006). In transparent (shallow) orthographies, the relationship between the Grapheme-phoneme is direct and the correspondence of the text with the reading is very predictable. In fact, in a perfectly transparent orthography, there is one Grapheme for each phoneme, and the number of phonemes corresponds exactly to the number of Graphemes. On the other hand, there are languages in which the Grapheme-phoneme relationship is one-to-many, and the correspondence of the text to reading is less predictable and has an opaque (deep) orthography (Wimmer & Goswami, 1994). Some alphabetic systems, such as Persian and Arabic, are transparent (Baluch, 2006). The Persian language is important because it has a perfectly compatible grapheme-to-phoneme correspondence, but it has a relatively inconsistent phoneme-to-grapheme correspondence (Rahbari, Sénéchal and Arab-Moghaddam, 2007). Rahbari (2018) has given a brief description of the Persian script in her article. In terms of reading, the Persian script is completely compatible, because each grapheme is compatible with one and always the same phoneme. However, it is not completely transparent because three letters of the vowel are not represented by a letter. In particular, the short vowels /a, e, o/ are not displayed with letters or definitions after the first years of training. In contrast, the vowels /ā, i, u/ are always represented by letters as a fixed part of words. Hence, words or syllables that have unmarked vowels are written as a sequence of consonants. Persian words in which all words are indicated by letters are shallow words and words that do not indicate vowels in letters, are named as vague words.

Studies have shown that dyslexia is associated with orthographic knowledge (e.g., Paz-Alonso et al., 2018; Temple et al., 2001). Bowers and Wolf (1993) showed that a lack of orthographic knowledge leads to poor performance in Rapid Atomized Naming (RAN) and reading difficulties. According to the Fifth Diagnostic and Statistical Manual of Mental Disorders (2013), dyslexia is a neurodevelopmental disorder that is characterized by slow and inaccurate word recognition and are not the result of sensory impairment, neurological impairment, IQ, or inadequate training (DSM-5, 2013). Estimates of the prevalence of dyslexia may vary from 5 to 15% (e.g., Rutter et al., 2004) and Pouretemad et al. (2011) reported this rate in Iranian monolingual children at 5.2%. Dyslexia persists throughout a person's life and interferes with their academic and professional success. Dyslexic students suffer from low self-esteem and depressive symptoms due to failure to acquire reading skills (Livingston, Siegel & Ribary, 2018).

Among the various theories of dyslexia pathology, the automaticity deficit theory has been proposed, stating that dyslexic children show a wide range of problems beyond mere reading disorder such as balance (Fawcett & Nicolson, 1992), motor skills (Fawcett & Nicolson, 1995) and rapid naming (Fawcett & Nicolson, 1994). These children have difficulties in gaining fluency for any motor or cognitive skills, such as reading or riding a bicycle, which should be automatized with practice (Fawcett & Nicolson, 2007). Cerebellum, which plays an important role in automaticity and control of movements; has been introduced as a major structure in automaticity deficit theory (Nicolson & Fawcett, 2018). Neuroimaging studies have shown that cerebellar activation is uncommon in dyslexic individuals (Linkersdörfer et al., 2012; Stoodley & Stein, 2013; Yang et al., 2013). In the study of Murdoch et al. (2010), imaging and clinical evidence of cerebellar deficits in various aspects of language processing are shown. In particular, given that the most common symptom of dyslexia is a reading disorder rather than a motor impairment, it makes sense to use language assignments to address this issue. Therefore, neuroimaging studies of language tasks have also been performed to investigate changes in cerebellar function in dyslexic readers. Feng et al. (2017) showed that the cerebellum does not function properly in dyslexic individuals during orthographic knowledge processing. However, some studies do not link cerebellar defects to language tasks (Desmond and Fiez, 1999).

On the other hand, implicit learning is closely related to automatic learning mechanisms (Conway & Pisoni, 2008). Nicolson and Fawcett (2011) suggested that implicit sequence learning deficit is caused by cerebellar dysfunction; It can explain the symptoms of learning and motor-sensory problems in dyslexia, and some researchers have recently begun to explore the possibility that an underlying implicit learning deficit may play a role in dyslexia (Howard et al., 2006; Kahta & Schiff, 2019; Menghini et al., 2006; Stoodley et al., 2006 Vicari et al., 2005;). However In individuals with dyslexia, some studies have shown that there is no such increase
One of the treatment interventions for dyslexia is cognitive rehabilitation. Cognitive rehabilitation is amplification or strengthening of cognitive processing through progressive cognitive tasks and/or environmental modifications (Farah et al., 2004). Given the above and reports of impaired learning impairment in dyslexic children, it prompts us to take steps to strengthen neurological factors. Program for Attentive Repetition for Memorizing Implicit Sequences (PARMIS) is designed to improve orthographic knowledge in these individuals. Therefore, the aim of the present study was to investigate the effect of parmis cognitive rehabilitation on improving orthographic knowledge of dyslexic students.

II. METHODOLOGY

The present study is a quasi-experimental study of pre-test-post-test with a control group. The statistical population of this study includes all dyslexic students in the second and third grades of elementary school in Babolsar city who were referred to learning disability centers in the 98-99 academic year. In this study, 30 subjects were selected by available sampling method and 15 people were randomly assigned to the control group and 15 people to the experimental group. Finally, due to the prevalence of corona samples, to 11 people in the control group and 14 people in the experimental group were reduced. Inclusion criteria of this study are experts' diagnosis, IQ 90 to 115 in Raven IQ test, right-handedness of people, education in the second and third grades of elementary school, no problem or physical disability that impairs the student's performance in the test and the criterion for leaving was irregular attendance at meetings. Among the ethical considerations observed were the ethical codes 4-8 and 5-8 of the ethical regulations of the Organization of Psychology and Counseling of the Islamic Republic of Iran, which are to participate in the research completely voluntarily and to avoid any negative consequences if people do not want to continue cooperation. Methods: First, with a complete description of the purpose and method of the research, their families were satisfied and they were also assured about the confidentiality of the information obtained. The subjects' questionnaire was completed by the parents. The questionnaire included information such as age, gender, educational background and dominant hand. After performing the reading pre-test, the researcher used the parmis cognitive rehabilitation program for the
experimental group for 5 sessions only. The intervention sessions started from 15 minutes according to the type of stage and in the final sessions due to the increase in difficulty level reached 45 minutes and were taught individually two sessions per week. At the end of the training course, the researcher obtained reading scores from both experimental and control groups. To analyze the obtained data, SPSS software version 22 and univariate analysis of covariance were used.

**Research Tools**

Raven Children's Progressive Matrix Test (Raven): Contains 36 color images, developed by Raven in 1956 and designed to assess the reasoning ability of children aged 5 to 11 years. The reliability of this test with the method of retesting and halving has been reported as 0.86 to 0.91, respectively (Rajabi, 2008).

Orthographic Knowledge Test: This test was developed by Rahbari, Sénéchal and Arab Moghadam (2007) to assess spelling knowledge. The test consists of 40 pairs of words, each of which contains a word with a correct spelling and a pseudo-word. This test contains 40 incompatible monographs; Includes 13 words with / s / phoneme; 11 words with the phoneme / h /; 5 words with the phoneme / t /; 6 words with the phoneme / z /; 2 words with / a / phoneme and 3 words with / gh / phoneme. It is the child's job to identify the word correctly by spelling it in pairs of words. The reliability of this test is reported to be 0.69.

The Parmis cognitive rehabilitation package (Nejati, 2017) is designed based on an intelligent repetition to memorize implicit sequences. In this study, sequential reaction time software has been used. Regarding the validity and reliability of this tool, it can be said that this test is not dependent on culture (Robertson, 2007) and on the other hand, the recordings are done by computer and human error not involved in registration. The software has four tasks: word sequence, non-word sequence, image sequence and number sequence. Each exercise has a set of hierarchical tasks of organization. The difficulty level of tasks is that, with the advancement of skill, tasks are becoming more difficult to advance. The software displays the stimuli on the screen with a certain order and records the reaction time and number of errors. At the beginning of the next session, after reviewing the performance of the individual in the previous session and in the event of a quorum (80%), it is allowed to enter the next stage at that session. Stimuli appears on the computer screen and the person must respond to the stimuli with the index finger of the dominant right hand by clicking on it. Each task is repeated 10 times per phase (10 blocks). Each block consists of a number of sequences that each sequence contains number of stimuli, that this number will increase by advancing in the steps. That is, the number of stimuli, and the number of sequences in each block gets increase. For example, in the first stage of the intervention of number sequence task, the experiment consists of 10 blocks and each block contains the sequences of 4 stimuli. All blocks followed a specific sequence. The specific sequence and pattern of appearance of stimuli are 1, 5, 4, 2 (in number sequence task). The next steps of the intervention are given in Table (1). In this version, in order to reduce the possibility of using explicit strategies, while performing the motor task related to implicit learning, the subject has a time interval between responding to one stimulus and the emergence of the next stimulus. Approximate test time is 15 minutes in first intervention step and by advancing in stages, this time will reach to 45 minutes. Response time is a measure of learning speed and time of correct answers is a measure of learning accuracy.

### Table 1. Intervention steps

<table>
<thead>
<tr>
<th>Intervention stage</th>
<th>Number of stimuli per sequence</th>
<th>Number of sequences per block</th>
<th>Number of blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>4</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Step 2</td>
<td>5</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Step 3</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Step 4</td>
<td>7</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Step 5</td>
<td>8</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

### III. FINDINGS

The participants’ descriptive information is presented in Table 2. According to the results, average scores of age and intelligence of participants in two control groups and tests have no significant difference (p> 0.05).

### Table 2. Central indicators of age and intelligence of participants in the experimental and control groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>group</th>
<th>X±SD</th>
<th>p</th>
</tr>
</thead>
</table>
Table 3. Mean and standard deviation of orthographic knowledge variable in dyslexic students in experimental and control groups in pre-test and post-test (n = 25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step</th>
<th>group</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthographic knowledge</td>
<td>pre-test</td>
<td>Examination Group</td>
<td>20.86</td>
<td>4.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control Group</td>
<td>19.73</td>
<td>3.82</td>
</tr>
<tr>
<td></td>
<td>post-test</td>
<td>Examination Group</td>
<td>22.57</td>
<td>3.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control Group</td>
<td>17.91</td>
<td>2.07</td>
</tr>
</tbody>
</table>

Table 3 shows the descriptive measurements of the mean and standard deviation of the orthographic knowledge variable in the experimental and control groups in the pre-test and post-test time periods. To determine the effect of group on post-test sizes, after separating the share of collected pre-test sizes for orthographic knowledge variable in dyslexic children, a univariate analysis of covariance was used. Before using analysis of covariance, for the design of analysis of covariance, the assumptions of linearity between the curvature and the variable were made and the homogeneity of regression was tested and confirmed. In addition, the assumptions of the Box's test of equality of covariance matrices and the Levene's test of equality of error variance were tested and confirmed.

Table 4. Results of the intergroup effects of orthographic knowledge in the post-test stage

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>F(df)</th>
<th>P</th>
<th>η2</th>
</tr>
</thead>
<tbody>
<tr>
<td>post-test</td>
<td>Orthographic knowledge</td>
<td>14.04 (1)</td>
<td>0.01</td>
<td>0.39</td>
</tr>
</tbody>
</table>

The results of univariate analysis of covariance to determine the effect of group on orthographic knowledge score of dyslexic students showed that effect of group factor on orthographic knowledge score[η2=0.39, P< 0.01, F= 14.04 (1)] was statistically significant.

IV. DISCUSSION AND CONCLUSION

The findings of the present study indicated that parmis cognitive rehabilitation caused a significant improvement in orthographic knowledge in the experimental group compared to the control group in dyslexic individuals. Lack of implicit learning has recently been suggested as a major cause of dyslexia (Nicolson & Fawcett, 2018). In the available research evidence, no article was found that directly addresses the effectiveness of this method on improving orthographic knowledge. Therefore, the findings are implicitly in line with the findings of some researchers that dyslexic people have a general impairment in implicit learning (Howard et al., 2006; Kahta & Schiff, 2019; Menghini et al., 2006; Stoodley et al., 2006; Vicari et al., 2005). Studies have also shown that the nature of orthographic knowledge is more tacit and seems to be learned implicitly (e.g., Pacton et al., 2005; Protopapas et al., 2017; Treiman et al., 2014).

Implicit learning is a cognitive function that is primarily processed by the cerebellum, and it is hypothesized that due to cerebellar defects, these individuals have difficulty automating any motor or cognitive skills (Nicolson & Fawcett, 2007). The cerebellum is active during various reading tasks and has been shown to be one of the main nodes in the reading network (Kujala et al., 2007). Studies have shown that dyslexic children show more extensive activity in the cerebellum than normal children (Linkersdörfer et al., 2012; Stoodley and Stein, 2013; Yang et al., 2013) and the results of the present study confirms the findings. One of these cognitive skills is orthographic knowledge. Feng et al. (2017) examined whether the cerebellum functions properly in dyslexic individuals during orthographic consciousness processing because there is growing evidence that the cerebellum is also involved in visual and spatial processing. In this study, they examined the activation of the cerebellum and cerebro-cerebellum during word processing in dyslexic individuals with orthographic tasks. In dyslexic children, more abnormal activity of the cerebellum was observed to perform orthographic processing, which was negatively correlated with normal individuals. The greater the reading disorder for dyslexic readers, the stronger the cerebellar activation. This indicates the compensatory role of the cerebellum in dyslexic children. In addition, more cerebellar connections to other parts of the brain; In particular, it was stronger between lobule VI of the right cerebellum and left fusiform gyrus during orthographic task. This pattern of results shows that the cerebellum compensates for reading disorders by communicating with specific areas of the brain. These findings enhance our understanding of cerebellar involvement in reading and reading disorders. However, some studies do
not link cerebellar defects to language tasks. For example, Desmond and Fiez (1999) suggested that the cerebellum does not play a direct role in accessing orthographic and phonological knowledge representations, semantic and syntactic information. As noted by Zeffiro and Eden (2001), the cerebellum is still not likely be the “culprit,” but rather an “innocent bystander” and the true underlying cause lies elsewhere. That is the cerebellar dysfunction may reflect defective processing from other brain regions such as the senses. On the other hand, the cerebellum is a large brain structure that contains half of all the neurons in the brain and has bilateral connections to almost all other brain regions (Ramnani, 2006). The cerebellum is highly connected with other brain regions related to reading such as left hemisphere reading network that includes the occipital-temporal cortex, the temporal-parietal cortex and the inferior frontal gyrus (Dehaene, 2009). Willingham (1998) shows that the basal ganglia, the cerebellum and the prefrontal cortex has been recruited in sequence learning. Thus, a possible cerebellar dysfunction might be compensated by the other structures.

Orthographic knowledge refers to the representation of spoken language in written form, stored in memory (Apel, 2011) and studies have shown that dyslexia is associated with orthographic knowledge (e.g., Paz-Alonso et al., 2018). Although many orthographic rules that help us read correctly are typically acquired through explicit instruction, the number and complexity of the combinations that the written language presents and required to become a skilled reader are large, and therefore implicit learning plays an important role in orthographic knowledge (Steffler, 2001). Overall, there is evidence that suggests that children must benefit from implicit learning mechanisms to extract the written language regularities in order to become proficient readers and spellers (Inácio, 2019).

Therefore, it seems that performing cognitive rehabilitation based on implicit sequences can stimulate and activate areas of the cerebellum and thus improve implicit learning in these individuals. In this program, children respond to cognitive stimuli with movement. Although the number of intervention sessions was limited to 5 sessions, studies have shown that this motor learning is associated with movement representation in the primary motor cortex. This representation is sensitive to both fast and slow experiences. The simple repetition of a specific movement, two movements together or a movement sequence in the fingers can quickly change the excitability of the primary motor cortex. This change in the cortex can occur in 5 to 10 minutes of rapid repetition of movements (Karni et al., 1998).

Conclusion

Overall, the findings of this study indicate the effectiveness of Parmis Cognitive Rehabilitation Program in improving orthographic knowledge in dyslexic children and can be a quick, safe and inexpensive solution to improve the reading of these students. The limitation of the present study is that the study population and sample were only second and third grade elementary children, which limits the generalization of results to other age groups. Also, selecting an available sample and not paying attention to gender characteristics were other limitations of this study; therefore, it is suggested that the effectiveness of parmis cognitive rehabilitation program be done in different age ranges and according to gender characteristics. It is also practically suggested to include similar programs for dyslexic children. It is also suggested that the effectiveness of this program on improving the orthographic knowledge of dyslexics in other languages be studied.

Gratitude

The present study is taken from a master's thesis from Shahid Beheshti University. The sincere cooperation of the education officials of Babolsar city, parents and children who participated in the interventions is highly appreciated.

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