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Original Article

Phonological Working Memory in 4-8 Year-Old Persian Children Who stutter

Maryam Vahab[1], Karim Shojaei[2*], Alireza Ahmadi[3], Mohammad Nasiri[4]

[1]Instructor, Department of Speech Therapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Department of Rehabilitation Management, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran
[3]Department of Speech Therapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[4]Department of Rehabilitation Management, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

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ABSTRACT

Background: One language-related area that has recently received more attention from researchers working in the field of stuttering is phonological working memory. This article aimed to identify phonological skills of working memory in children with stuttering in comparison with normal children, and to obtain the relationship between the increase in the number of syllables in non-words and the mean percentage of error in non-word repetition in both groups, then to compare them with each other.

Methods: Thirty children participated in the study, 15 children who stutter and 15 normal children which were matched by age, gender and socio-economic status. Cases of this study were recruited by non random convenience sampling. The research data collection was based on non-word repetition test. The test included 40 non-words. Independent t-tests and linear regression were used for data analysis.

Results: Results revealed that in all cases the mean percentage of error was higher in children who stutter than normal children, but the difference was not statistically significant (P>0.05). Also the mean percentage error did not show a regular increase by increasing the number of syllables in the non-words. So that, in both groups of the study the highest mean percentage of error was related to single-syllable non-words then three-syllable and two-syllable ones.

Conclusion: The results of the present research from previous researches support the view that children with stuttering may have some degree of delay and slow in phonological working memory abilities when compared to normal children. It is proposed that in future more researches could be done in more samples, in different age groups of children and adults who stutter.

Introduction

Linguistic issues are reported as one of the most important factors in the etiology of stuttering in the past few decades [1-5]. Recently working memory has been implicated in the development of stuttering. [6]. Working memory is universally recognized as neurocognitive system that provides temporary storage and processing of incoming information. Envisioned working memory as a multicomponent neurocognitive system includes a central executive, visuo-spatial sketchpad and phonological loop [7]. The phonological loop includes short term storage and rehearsal of incoming verbal information to enable comprehension. Phonological encoding during speech planning involves retrieving phonological material from storage to build articulatory plans [8]. One prominent

*Corresponding author: Karim Shojaei, Department of Rehabilitation Management, School of Rehabilitation, Shah nazari St, Mother Sq, Mirdamad, Tehran, Tel: +98 21 15772222,
E-mail: shojaei.k@tak.iums.ac.ir

theory which is the covert repair hypothesis of Postma and Kolk (1993) assumes that stuttering arises because inefficient or slow phonological encoding leads to an increase in covert repairs to the phonological plan, particularly when the individual is intent on speaking at a rate exceeding the compliance of the phonological encoding mechanism. Covert repair hypothesis is essentially a psycholinguistic hypothesis [9]. According to Kolk and Postma stuttering is a response to the excessive number of errors or mistakes in the speaker's voice pattern. Response to these errors is in form of hidden attempts to correct them [10]. This does not mean impairment in self-control or error detection in people who stutter and theirs error in phonological planning are not different from normal people. Rather people who stutter make more mistakes and consequently need more corrections. So repetition of sounds and syllables occur in stuttering are attempts to reconstruct or correct errors and repetitions or restarts as a way or a strategy to correct or decrease coding errors and stuttering is a reviser reaction to the abnormal phonological programming. Kolk and Postma stated that the nature of this reconstruction in people who stutter is associated with phonological not motor factors. They believe phonological growth and phonological coding is slower in people who stutter compared to normal people. The deviation from the normal speech leads to a greater number of errors in the phonological programing in people who stutter [10]. Based on the covert repair hypothesis, the main problem with stuttering is language system or the cycle of phonology cycle in the process of speech production, and Phonological working memory is measured with repetition of non-words [10, 11]. A few researches have been done in this filed but there are controversy results. Bosshardt (1993) performed a study with a group of adult people who stutter and a control group. In their study, participants should write four CVC syllables that were repeated after each other, once they were presented; while an intervening stimulus were also entered. He reported that adult people who stutter produced significantly fewer syllables in right position compared with the control group. Finally results showed that adult people who stutter showed poorer phonology and need more phonological revision time than people without stuttering [12]. In a study conducted by Anderson et al. (2010) the ability of repeating non-words was assessed in normal children and children who stutter. Results showed normal children ability to repeat non-words was different from individuals who stutter, and the difference was related to poor language performance in children who stutter or occurring stuttering in periods that non-words are repeated [13]. In another research, Hakim and Ratner (2012) tested Phonological working memory ability in 4 to 8 year-old children using children non-words repetition test. They reported that by increasing the length of the syllables, children who stutter significantly repeated fewer items correctly and showed more phonological errors than fluent children but fluency of non-words didn't change by increasing length of non-word. Also children who stutter were fluent in long non-words just as short ones [14]. Few researches in Persian language in this filed have been done. Bakhtiar et al (1390) examined phonological encoding in 12 children who stutter and 12 children without stuttering through non-word repetition task. Their results indicated that children with stuttering showed slightly poorer performance when compared to non-stuttering children but the difference was not significant [15]. In another study performed by Barik rou et al. (1390), 30 children 4 to 6 years of age stutterers were compared to 30 normal subjects who were matched for age. Analysis between two groups revealed great differences in all indicators except non-words [16]. With regard to the importance of the discussed issues about non fluency, researchers intended to examine phonological memory of non-fluent children and their errors in comparison with a control group of children, applying non-word repetition test for non-fluent children.

Methods

This cross sectional study was performed through a non random sampling. Accordingly, 15 children who stutter (12 boys and 3 girls) with mean age of 53/5 years participated and 15 normal children (12 boys and 3 girls) with mean age of 5/53, participated in the study. Gender, age and social status of normal children were matched with individuals who stutter. Non-fluent cases were all selected from private and public speech therapy and counseling clinics. With following exclusion criteria: No history &/or presence of delayed language development, dyslalia, mental retardation, hearing impairment, psychological problems or neurological problems. In a period of 4 months all private and public speech therapy psychological, counseling and other related clinics were under consideration. Nineteen 4-8 year-old visitors of the clinics were introduced to the researchers through negotiations with authorities and therapists of the clinics. Finally 4 individuals who stutter that couldn't pass the research criteria were omitted (Due to the exclusion criteria such as disarticulations problems and ...). Control group was selected randomly from Shiraz kindergartens at the same time. All participants were subjected to the following protocol of assessment:

1-Personal data questionnaire:

A questionnaire was filled for each examinee to obtain information such as date of birth, basic education, sex, general health status, language or accent - which the individual speaks, history of stuttering, and etc.

2- an informal short memory test was done to be sure that the participants could repeat 3 syllabic words or non-words.

3-non-word repetition test:

In current research 40 non-word were used as stimuli which included 10 one syllable, 15 two syllables and 15 three syllables non-words. These non-words were selected from Barikroo et al. [16]. And a research related to normalization of repetition non-word test for children who stutter conducted by Sayyahi et al. [11]. According to Sayyahi et al these non-words had been generated from two and three syllabic Persian language words by changing one or two consonants in them until they could not convey the

semantic issues of the word. Also, the phonetic structure of the non-words conformed to the usual Farsi pattern. The non-words included a variety of phonemes and syllables in the Persian language (cv, cvc, cvcc).

3-Longwaves software

Audio recording of stimuli was performed by longwaves software. Longwaves is a software with high quality of sound analysis. The software was used to record speech samples and calculate number of correct and non-fluent non-words.

The participants were examined in a quiet setting in one session lasting approximately 40-60 min. In order to ensure a fresh state of mind in the children, we performed the experiment in the morning for all the subjects .The test was performed when examinees passed interval criteria of the study. At first, the required explanations was presented for each participants about how they should answer the task. The examiner gave the following instructions to the children: 'I want to say some funny made-up words to you. Repeat them after me exactly the way that I say them as soon as possible. Then five examples of non-words were given by the examiner and the child was asked to repeat each. Once the 40 non-words were presented. When repeating non-words, in addition to responses transcribed by the researchers, the sound of children was also recorded by Longwaves software. Then, recorded audio files were analyzed. Finally, the number of phonological errors and correct responses were identified.

Statistical Analysis

At first Kolmogorov-Smirnov was used to evaluate data distribution. After confirming the normal distribution of data, independent t-test applied to compare the two groups. Then paired t-test was used to determine significant differences between each pairs of three sets of data (single, two and three syllables) in each group.

Results

Comparing total mean percentage error indicated that this value in non-fluent group (45±22) was more than normal group (33±17) but not significantly different (P>0.05) (Table 1).

Based on the obtained results in the non-fluent group, the minimum mean percentage error occurred in repetition of the two-syllable non-words (30±19). The maximum mean percentage error occurred in repetition of the three-syllable non-words (42±14). In the normal group, the minimum mean percentage error occurred in repetition of the two-syllable non-words (21±14) and the maximum mean percentage error observed in one-syllable non-words repetition (31±15). Comparing the mean percentage error between the two groups determined that the maximum mean percentage error occurred in one-syllable non-word repetition (42±14), and the minimum mean percentage error observed in 2syllable non-word repetition (21±14).

After measuring the total mean percentage error in two groups and in single, two and three syllable non-words, it was determined that the maximum percentage error was found in single-syllable and two-syllable non-words repetition and minimum percentage error were observed in repetition of the two syllable non-word.

Data are presented in Table 2.

There was significant difference between the mean percentage error of thee syllable non-word repetitions and two syllable ones (P<0.017) but no significant differences were found between one syllable non-word repetition and three syllable non-words and between one syllable non-words and two syllable ones (P>0.017).

According to the Table 3 in the normal groups, there was a significant difference between repetition of three syllable non-words in comparison with the two syllable non-word repetitions (P<0.017) but significant differences were found between one syllable and three syllables, and between one syllable and two syllables (P>0.017).

Based on the Table 4. Mean percentage error was compared among one syllable, two syllable, and three syllables two by two. Numbers above diagonal shows P value and numbers under diagonal shows t-value.

According to the Table 4, the mean percentage error of three syllable non-words repetition were significantly higher compared to two syllable non-words. Significant differences was also found between two syllable and one syllable non-words repetitions

Table1: Comparison of mean percentage error of non-word repetition in two groups of non-fluent and normal

Group	Non-fluent	Normal	P value
Mean percentage error	22±45	17±33	0.38

Table 2: Mean percentage error in whole population under the study based on the number of syllables

Non-word length	One syllable	Two syllable	Three syllables
Mean percentage error	37±15	25±18	35±20

Table 3: Comparison of the mean percentage error of non-word repetitions based on the number of syllable in the normal group

	Number of syllables	One syllable	Two syllables	Three syllables
Number of syllables	Mean percentage error	31±15	21±14	30±17
One syllable	31±15	***	0.022	0.88
Two syllables	21±14	2.57	***	0.15
Three syllables	30±17	0.15	-2.7	***

Table 4: Comparison of non-words repetition mean percentage error based on the number of syllables in the non-fluent group

	Number of syllables	One syllable	Two syllables	Three syllables
Number of syllables	Mean percentage error	42±14	30±19	40±21
One syllable	42±14	***	0.009	0.64
Two syllables	30±19	-3.05	***	0.002
Three syllables	40±21	-0.47	-3.75	***

(P<0.017). But, there was not significant differences between repetition of the one syllable and three syllable non-words (P>0.017).

Discussion

According to the results of the study, in repetition of non-words, there was no significant difference between the mean percentage error of the two groups of normal and individuals who stutter. Despite the significant difference in repetition of single-syllable non-words between the two groups, no significant differences were found in the mean percentage error among repetition of two and three syllable non-words. These findings were different from Hakim and Ratner's result (which indicated that children who stutter show more phonological errors. The results were also different from the findings of Aboul oyoun et al. stated that in repetition of two and three syllable non-words, children who stutter made more error when compared with normal children [6]. But, it was consistent with the result of Bakhtiyar et al., their results showed no significant difference statistically.

Based on the results of the current study, most percentage error was over single syllable non-words and then on three and two syllable non-words which indicated in both groups of normal and children who stutter; number of error would not increase when length of the non-words increased. These findings were consistent with Hakim and Ratner but contrasted Barikrou results that showed the percentage error increased as well as increase in the non-word length [16]. Results of the study were also in contrast with the result of Bakhtiyar et al. that stated the number of error increased when the length of non-word increased [17].

According to the results, in fluent individuals, the maximum percentage error was over single syllable and then on the three syllable and two syllable non-words which shows the number production error does not increase with increasing the length of non-words. These findings were somewhat consistent with the studies conducted by Hakim et al.; Anderson et al. and Bakhtiyar et al.

Lack of cooperation from the subjects or their parents, no special centers for treatment of these individuals, lack of adequate space in some medical centers to test, noises during the test and the speech record, and not having control on stuttering severity were the research limitations.

It is proposed to do the research with more samples in different age group of children and adults who stutter. Comparing the reaction times of repeating non-words is suggested in a subsequent study.

Conclusion

In spite of non-significant differences, evidence from current study showed differences between the two groups of fluent and non-fluent children. It proposed the possibility of defects in non-fluent children language processes, especially in their phonological encoding mechanism in production of words. Specially because, increasing the sample size may make difference in significance value between the two groups.

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Conflict of Interest: None declared.

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