

Comparing attention, Working Memory and Reaction Time in Children with and Without Childhood onset fluency Disorder

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Abstract

The childhood onset fluency disorder is of the most prevalent verbal disturbances. This disorder causes prolonging and repetition of words and defects speech fluency. The presents research aims at comparing the sustained attention, working memory, and reaction time in children with and without childhood onset fluency disorder. Therefore, this research is comparative. Two sample populations comprising the twenty 7-12-years-old children with and the twenty 7-12-years-old children without childhood onset fluency disorder were selected from among two research populations, considering the intended criteria obtained by the researcher-made questionnaire for testees' inclusion. Then, the data of two groups were collected using the research tools, i.e., Continuous Performance Test (CPT) and N-Back test, to assess the sustained attention and reaction time and the working memory, respectively. SPSS software and independent t-test were applied for data analysis. Comparing two groups revealed that the sustained attention and working memory in the children with childhood onset fluency disorder are different and less than the ones without such disorder. Further, the results showed that the reaction time in the children with childhood onset fluency disorder was similar to ones not suffering from such disorder.

Keywords: Childhood onset fluency disorder, attention, working memory, reaction time.

INTRODUCTION

According to DSM5, the childhood onset fluency disorder is a state-recognized by a disturbance in ordinary speech fluency, and the individual commits pronunciation timing error. This problem does not correspond to the individuals' age and speech skills, which exaggerates by passing the time. The symptoms are revealed at early infancy and childhood periods. These problems cannot be attributed to sensory or motor speech disorder, childhood onset fluency disorders resulting from neurologic difficulties such as brain stroke, tumor, trauma, or other medical complications. Moreover, another mental disorder cannot justify that (American Psychiatric Association, 2013).

The studies show that the reaction time in the group with childhood onset fluency disorder is different from the ordinary group. Anderson and Vagovic (2016) studied forty-one 3-6 years old children with and without childhood onset fluency disorder. The results revealed that the children with childhood onset fluency disorder show a slower reaction. In contrast, Byrd et al. (2007) revealed that the group with childhood onset fluency disorder show faster reaction time in response to comprehensive cueing, regardless of their age. Hartfield and Conture (2007) concluded that the children with childhood onset fluency disorder show slower reaction time than the children the same age as them. The findings of Farazi et al. (2014) indicate that the children with childhood onset fluency disorder revealed weaker and slower reaction time and time of naming the

fourfold task (including pictures, colors, numbers, and letters) in comparison to the ones without such disturbance.

The working memory is a multi-component system that includes the visuospatial sketchpad, central executive, and phonological loop, each of which has its components. The phonological loop deals with the short-term storage and verbal input information review that involves the speech perception and reception process and analysis of language vocal elements (Seif Panahi et al., 2015). The studies have revealed that one of the problems of children with childhood onset fluency disorder is language impairment which is created due to impaired working memory. The results of research on the relationship between working memory and speech fluency indicated that individuals with low working memory spans had less speech fluency and further speech-error probabilities. These studies revealed considerable differences between individuals' working memory with childhood onset fluency disorder and those without such disturbance (Seif Panahi et al., 2015).

Sustained attention is a process that enables the maintenance of response persistence and continuous effort over a long time (Yu et al., 2017). It seems the attention acts by the increase of target neural activities on the top threshold and the decrease of other neurons that results in the perceptual-emotional system activity (Carothers, 2013). Further, many researchers believe in the relationship between attention problems and childhood onset fluency disorder in individuals with such disturbance. Some scholars showed that the attention deficit is revealed in the children with childhood onset fluency disorder, and the divided attention is considerably disordered in such individuals (Egger et al., 2013; Andres et al., 1988; Esfandeh et al., 2014). Moreover, many studies have been done about the relationship between attention and childhood onset fluency disorder. The results of a meta-analysis revealed that the attention of individuals with an childhood onset fluency disorder is generally lower than those without such disorder (Doneva, 2020).

This research subject is selected considering the researchers' interest in the subject of speech and language and complexity of childhood onset fluency disorder, on one side, and its considerable influence on the individuals

affected by such disorder and also concerning this matter that this subject is an interdisciplinary issue disregarded by the psychologists. Regarding what was mentioned, the present research aims to compare the attention, working memory, and reaction time in children with and without childhood onset fluency disorder.

Research theoretical foundations

Childhood onset fluency disorder

The childhood onset fluency disorder is observable in at least 5 percent of 3-6 years-old children (Sommer et al., 2021). The number of boys who stutter increases by 3-4x more than the girls as children reaches about 2 to 7 years of age, and the most frequency of disfluency occurs about five years of age. Generally, 98 percent of such disorders begin before the age of 10 and gradually develop (Salehi et al., 2012).

The children who stutter are less accepted socially than their typically fluent peers, less likely to be perceived as leaders, and have fewer friends (Birstein, 2015). Klompas and Ross (2004) studied the life quality of the small group of adults with onset fluency disorder in South Africa, applying multidimensional measurements including job, self-esteem, marital status, family and emotional status, and social performance. They found that although the onset fluency disorder does not negatively affect the family's excitement level or individuals' marital relations, it negatively influences these individuals' self-esteem and emotional consistency. Nikkhah and his colleagues (2013) findings showed that the average scores of physical health, mental health, and life quality in the individuals with childhood onset fluency disorder is meaningfully lower than the average score of their fluent peers.

Many factors such as environmental, psychological, physiological, and biological factors affect speech fluency disorder. Kanter has divided the neurological fluency disorder into three subcategories. One is dysarthria which is revealed in individuals affected by Parkinson's and brain damage. This dysfluency results from a loss of muscle control, such as primary dysarthria. The second subcategory is apraxia which might result from a critical problem in motor planning. The silent blocks and repetitions occur due to the speaker's effort to provide continuous speech movements. The third subcategory is dysnomia that sometimes happens along with aphasia (Guittar, 2014).

Reaction time

The reaction time is one of the dimensions of executive functions that have been considered in the study of a childhood onset fluency disorder. The reaction time is a criterion that shows the nature of phonatory differences between the fluent individuals and the stuttering ones. Therefore, the relationship between the phonatory and the childhood onset fluency disorder can be examined by studying the phonatory reaction time in the individuals with and without such disorder since studying these parameters leads to a better perception of childhood onset fluency disorder (Nikkhah et al., 2013). Reaction time, defined as the time between the application of a stimulus and the beginning of an organism's response to it, is an indicator of the central nervous system's ability to receive and synchronize movement expressed through the peripheral nervous system (Roach et al., 2014). Anderson and Vagovic (2016) studied forty-one 3-6 years old children with and without childhood onset fluency disorder. The results revealed that the children with childhood onset fluency disorder show slower reactions and weaker performance in their implicit activities than their fluent peers.

Sustained attention

Sustained attention is a process that enables the maintenance of response persistence and continuous effort over a long time (Yu et al., 2017). Sustained attention is the basic attention function that recognizes the influence of higher attentive aspects and recognition capacity, such as selective and divided attention (Sarter et al., 2001). Many researchers believe in the relationship between attention problems and childhood onset fluency disorder in the individuals affected by such disturbance. The attention disorder is observed in children with a childhood onset fluency disorder. Some scholars remark that individuals with childhood onset fluency disorder show more attention in comparison to their fluent peers. For instance, Vasic and Wijnen (2005) stated that if the individuals with childhood onset fluency disorder are sensitive to the speech error probability due to the further consideration of their speech, this can indicate their more ability in the control of attention or even their higher attention ability.

In contrast, many scholars believe in the relationship between attention problems and

childhood onset fluency disorder in the individuals affected by such disturbance. The attention disorder is observable in the children affected by such dysfluency (Egger et al., 2013). The study results done by Eichorn and his colleagues (2017) revealed that the children with childhood onset fluency disorder show slower attention change and more anxiety toward their mistakes compared to their fluent peers. Bosshardt's (2006) results indicated that the individuals with childhood onset fluency disorder recognize the semantic information slower than the ones not affected by such disorder. Further, the individuals with childhood onset fluency disorder tend to produce sentences including words limited in number when doing two works simultaneously.

Working memory

The working memory is a multicomponent cognitive system that enables individuals to retain the information against the irrelevant stimuli and manipulate them to access a purposeful activity (Hasanzadeh & Ahmadi 2015). The working memory is a small piece of information that can be used for cognitive activities. In contrast, long-term memory includes a large amount of information stored during an individual's life. Working memory is one of the most important subjects in psychology. It often is attributed to intelligence, information process, executive functions, reception, problem-solving, and learning. It is appeared in different years of age, from childhood to adulthood, even in the animals (Cowan, 2014).

Bajaj (2007) studied the relationship between working memory and speech fluency. The results revealed that the individuals with lower verbal working memory span showed less verbal fluency and more speech errors. The results of the study done by Seif Panahi et al. (2015) revealed a relationship between working memory, visual memory, and verbal memory with the severity of speech fluency disorder. Moreover, there observed a positive relationship between age and the childhood onset fluency disorder severity. It means that the fluency disorder level is increased as age increases. The findings of this research confirm the negative influence of numerical, visual, and verbal working memories deficit on the childhood onset fluency disorder intensity and the negative effect of age increase on the childhood onset fluency disorder. This indicates that both of these factors have a direct relationship

with the increase of childhood onset fluency disorder.

Research methodology

The presents research aims at comparing the sustained attention, working memory, and reaction time in children with and without childhood onset fluency disorder. Therefore, this research is comparative. Two sample populations comprising the twenty 7-12-years-old children with and the twenty 7-12-years-old children without childhood onset fluency disorder were selected from among two research populations, considering the intended criteria obtained by the researcher-made questionnaire for testees' inclusion. Then, the data of two groups were collected using the research tools, i.e., Continuous Performance Test (CPT) and N-Back test, to assess the sustained attention and reaction time and the working memory, respectively.

In this research, convenient sampling was applied, and forty 7-12-years-old children settling in Tehran city were selected. Of this population, the elementary schools introduced three students (experimental group) and 6 students (control group), and 20 children without childhood onset fluency disorder. Further, 5 and 3 students were respectively introduced by Eksir Speech Therapy Clinic as the experimental and control groups. In addition, the Speech Therapy Clinic of the School of Rehabilitation Sciences of Iran University introduced 2 and 1 students as the experimental and control group, respectively. Finally, 20 members were selected for every sample size using the Sample Size Determination formula, regarding the % five significance, %80 test power, and 0.9 effect size. N-BACK test was applied for testing the fluent children's working memory. Further, the Continuous Performance Test (CPT) was used for testing the sustained attention and reaction time of these children.

Further, the children with childhood onset fluency disorder were evaluated by examining the percentage of stuttered syllables. The children with above-average levels (greater than or equal to 8 percent) of childhood onset fluency disorder were selected, and their behavioral, emotional, and familial characteristics, simultaneous disorders, and so forth were assessed. The individuals who had no problem in other aspects were extracted and were

randomly classified into two experimental and control groups. Then, both groups were examined by two N-BACK (used for measuring their working memory) and Continuous Performance Test (used for measuring their sustained attention and reaction time) methods.

The mothers of two groups with and without childhood onset fluency disorder were interviewed for 20 minutes, using a researcher-made questionnaire to collect the research data. Then, 40 monolingual right-handed children (20 of them with and 20 without childhood onset fluency disorder) who had not experienced the brain damage, clinical disorder, and mediating environmental factors were selected.

Working memory N-Back test

This test requires programming, temporary storing, and response since it is necessary that the individual easily access the information in the working memory for the storage and continual updating of this information. The stimuli are usually two or three recursive numbers presented from a visual or auditory N-Back perspective. It orders the participant to react when the current item is presented previously, and the status changes every time. This test is valuable since it does not represent a vocal response and can be used in individuals with linguistic changes (Goncalves & Mansur, 2009).

The N-back task was originally introduced by Kirchner (1958). This task comprises the maintenance and manipulation of cognitive information and has been well known for assessing the working memory function. The validity coefficients revealed the high validity of this test in a domain between 0.54 and 0.84. Further, the reliability of this test as an index of working memory performance measurement is considerably acceptable (Kasayian et al., 2014).

Continuous Performance Test (CPT)

This test was used for measuring sustained attention and reaction time. The Persian version of this test is performed using the computer and includes 150 Persian numbers as the stimuli, thirty of which (20 percent) are target stimuli. The distance of presentation of two stimuli is 500 milliseconds (ms), and the presentation of every stimulus takes 150 milliseconds. The validity coefficients (retest) of different test parts were applied to 43 male elementary school-aged students within 20 days. It is located across 0.59 to 0.93 domains. All the coefficients calculated at 0.001 significance level have a meaningful

correlation. The test validity was evaluated using the criterion validation method, comparing the norm group (30 male elementary school students) and the one with Attention-Deficit/Hyperactivity Disorder (25 male elementary school students). The statistical comparison of two groups' averages in different test parts revealed meaningful differences between the two groups' performance ($p < 0.001$). (Hadianfard et al., 1990). SPSS software and t-test were used for analyzing the research data.

Findings

In this section, the descriptive and inferential statistics were first examined in the case of research hypotheses.

The results revealed that the average working memory score in the groups with and without childhood onset fluency disorder is 72.50 and 78.20. The average score of sustained attention in the groups with and without childhood onset fluency disorder is respectively 141 and 144.60. Further, the average reaction time score in the groups with and without childhood onset fluency disorder is respectively 580.05 and 537.45.

First, the assumptions of the independent t-test were examined.

As it is observable in table 2, the assumption of normalness of research variables distribution with a significance level greater than 0.05 ($p > 0.05$) was confirmed by using the Shapiro-Wilk test in the variables of sustained attention, working memory, and reaction time in both groups with and without childhood onset fluency disorder. Further, Levine's test was applied for examining the assumption of the equality of variances.

Table 3 represents the results of Levine's test applied for examining the homogeneity of error variances. According to the obtained results, the significance level of working memory and sustained attention variables is greater than the significance level 0.05 ($p > 0.05$). Therefore, the assumption of homogeneity of variances in these variables is not confirmed.

Considering the results of independent t-test assumptions, since both assumptions in the case of the relationship between attention and memory variables were confirmed, the independent t-test was applied for examining them in both groups with and without childhood

onset fluency disorder. Further, because the assumption of homogeneity of variances error was not confirmed in the case of the reaction time variable, Walsh's test was used for examining this variable in two groups with and without childhood onset fluency disorder.

The results of table 4 reveal that the p-value obtained for the attention and working memory variables is less than the critical level of 0.05. Therefore, it can be concluded that there is a meaningful difference between the variables of sustained attention and working memory in the children with childhood onset fluency disorder and their fluent peers. However, the p-value obtained for the reaction time variable is greater than the critical level of 0.05. So, it can be concluded that there is no meaningful difference between the reaction time of the children with childhood onset fluency disorder and their fluent peers.

Conclusion

The present research compares the sustained attention, working memory, and reaction time in children with and without childhood onset fluency disorder. The results of this comparison revealed that sustained attention is different in children with childhood onset fluency disorder and their fluent peers. Their attention is meaningfully less than the fluent children. Many pieces of research have been done about this subject, and paradoxical results have been obtained. Some studies showed no meaningful difference between the attention of children with childhood onset fluency disorder and their fluent peers. Oppositely, many researchers believe in the relationship between attention problems and childhood onset fluency disorder in the individuals affected by such disturbance. The results of a meta-analysis done by Denova (2019) revealed a meaningful correlation between attention problems and the stutter. The results of a study done by Eichorn and his colleagues (2018) revealed that children with childhood onset fluency disorder show slower attention change and more anxiety toward their mistakes than their fluent peers. Furthermore, Egger and his colleagues (2013) showed that attention disorder is observable in the children affected by such dysfluency.

On the contrary, some studies have revealed that the attention of children with an childhood onset fluency disorder is not lower than their fluent peers, and it is even more in comparison to them.

For instance, Vasic and Wijnen (2005) stated that if the individuals with childhood onset fluency disorder are sensitive to the speech error probability due to the further consideration of their speech, this can indicate their more ability in the control of attention or even their higher attention ability. In addition, the results of the study accomplished by Maxfield et al. (2016) revealed that individuals with childhood onset fluency disorder pay more attention to speech production than their fluent peers.

Furthermore, the present study results revealed that the working memory is different and less in the children with childhood onset fluency disorder compared to their fluent peers. The results obtained in this research correspond to the other studies. The results of research done by Bajaj (2007) about the relationship between working memory and speech fluency revealed that the individuals with lower verbal working memory span showed less verbal fluency and more speech errors. In addition, the results of the study done by Ofoe, Anderson, and Ntourou (2018) revealed that children with childhood onset fluency disorder have a cognitive process such as impaired verbal working memory.

In addition, the results of comparing the children with childhood onset fluency disorder and their fluent peers revealed no difference in the reaction time of children with childhood onset fluency disorder compared to their fluent peers. Some studies' results correspond to the findings of the present research. Anderson and Wagovic (2016) found out that there is no relationship between the number of words and the processing speed in children with a childhood onset fluency disorder. Melnick et al (2003) showed that both groups with and without childhood onset fluency disorder show a higher level of verbal reaction time about 3 to 5 years of age whether a phonetic sound clue is given, not given, or an irrelevant clue is given. The study results were done by Anderson and Wagovic (2016) on forty-one 3-6 years old children with an childhood onset fluency disorder, and their fluent peers revealed that the children with childhood onset fluency disorder show slower reaction time. The results of Hartfield and Conture (2006) study revealed that the children with childhood onset fluency disorder generally show slower reaction time than the children the same age as them.

Regarding the obtained results, future researchers are suggested to measure the other aspects of executive functions, including problem-solving, planning, argumentation, organization, and other factors in the childhood onset fluency disorder. Concerning this matter, speech therapy and sometimes pharmacotherapy are considered the prevalent therapies of childhood onset fluency disorder; it is suggested to compare the efficiency of these therapies and the treatments' sustainability during the research time.

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Table 1. Pretest descriptive statistic in two groups with and without childhood onset fluency disorder

Element	Group	number	average	Standard deviation	Standard error
Working memory	Without fluency disorder	20	78.20	10.675	2.387
	With fluency disorder	20	72.50	13.268	2.967
Attention	Without fluency disorder	20	144.60	4.096	0.916
	With fluency disorder	20	141.00	5.120	1.145
Reaction time	Without fluency disorder	20	537.45	104.463	23.359
	With fluency disorder	20	580.05	161.466	36.105

Table 2. Shapiro-Wilk test for testing variables' distribution normalness

Element	group	W	significance
Working memory	Without fluency disorder	0.923	0.114
	With fluency disorder	0.952	0.396
Attention	Without fluency disorder	0.812	0.206
	With fluency disorder	0.938	0.222
Reaction time	Without fluency disorder	0.939	0.233
	With fluency disorder	0.943	0.270

Table 3. Levine's test for examining homogeneity of variances

	F	Degree of freedom	Significance
Working memory	1.859	1	0.181
Attention	3.002	1	0.091

Reaction time	4.255	1	0.046
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Table 4. T-test inferential statistic for testing average values difference in two groups

	Test	Stand ard error	Degr ee of freed om	P	Spatial param eter	Stand ard error differe nce
Attent ion	Stud ent	2.455	38.00	0.0 19	3.600	1.466
Work ing memo ry	Stud ent	-0.079	38.00	0.0 38	-0.300	3.808
React ion time	Wel ch	-0.991	32.53	0.3 29	-42.600	43.002