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Efficacy of Training of Executive Functions (Working Memory) on the Rate of Attention in Preschool Children with Developmental Coordination Disorder

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Abstract

Background: The present study aims to investigate the efficacy of executive functions training (working memory) on the rate of attention in preschool children with developmental coordination disorder in Isfahan city.

Materials and Methods: The participants of this study were three preschool children which were recognized to have developmental coordination disorder. To collect data used NEPSY neuropsychology test, Conner's parent rating scale, Wechsler intelligence scale for children, basic motor ability tests and clinical interview.

Results: The results of the data chart analysis based on descriptive statistics' and visual analysis indices revealed that the intervention has been effective on the three participants [respectively PND (Percentage of Non-Overlapping Data) 80, 70 and 50% for test number one, two and three].

Conclusion: The results of the present study show that working memory executive function training, the rate of attention deficit can be reduced.

Introduction

The developmental coordination disorder (DCD) is a term used to explain the problems faced by individuals in developing motor skills. Such problems exhibit themselves in early childhood in the form of difficulty in learning or acquiring skills that need motor functions coordination, and can negatively influence different aspects of a child's development. Among these difficulties is the attention deficit disorder, the timely diagnosis and treatment (through following a suitable therapeutic method) of which during preschool years, would be of particular importance [1].Attention is a series of complicated cognitive processes including concentration on or involvement with the goal, ability to maintain concentration, tolerance, and alertness towards a situation for a long time, coding the stimulus characteristics, and shifting concentration from one goal to another [2, 3].

Among the interventional methods used to treat attention deficiency in children with DCD is the executive functions training [4]. Executive functions training is a general term encompassing all complicated cognitive processes that are necessary for doing new and/or difficult goal-directed assignments [5]. It includes the ability to delay or inhibit a specific response and consequently plan action consequences as well as maintain cognitive representation of the assignments through the working memory [6]. Executive functions have various components, one of which is the working memory. Working memory is defined as the cognitive system responsible for temporary storage and processing of information. It is an important cognitive process which forms the infrastructure of thinking and learning in children and plays a sensitive role in their learning and attention [7].

In their research conducted by Michel et al. [8] titled "development of cognitive skills in children with motor coordination deficiency", the results showed the such children exhibit difficulty in executive functions, particularly with regard to inhibition and transitive functions. Belger and Banich [9] showed in their research that intervention through executive functions training (working memory, planning, and metacognition skills) was effective on improving mathematical performance of children with mathematical learning disabilities. Due to the insufficient efforts exerted so far to investigate the factors that cause motor control disorder in children with DCD, identification of and studying CDC-relevant executive functions seem to be absolutely necessary. The present research, with due regard to the findings of the above study, is primarily aimed at increasing the effectiveness of executive functions training (working memory) on the degree of attention paid by preschool children with DCD.

Materials and Methods

The single-subject methodology was used in the present research. The statistical population consisted of all the preschool children aged between 5 and 6 years and diagnosed with DCD, who had registered in the schools affiliated to Isfahan Education Administration in the 2011 academic year. Since this research would seek out special or unusual cases, the purposeful sampling method was used, i.e., the test subject selection was according to the

researcher's judgment based on the purpose of the study. Based on this, three preschool children diagnosed by the specialist to show symptoms of DCD were selected. The relevant questionnaires were consequently submitted to the children's parents upon their consent as well as observance of confidentiality. The tools used in this study to gather data for baseline, intervention, and follow-up assessments included the neuropsychological test NEPSY, the Conner's parent rating scale, Wechsler's intelligence scale for children, basic motor ability tests, and clinical interviews.

The neuropsychological test NEPSY: NEPSY is a comprehensive tool designed for the assessment of neuropsychological development in preschool and primary school children between 3 and 12 years of age. NEPSY includes a series of neuropsychological subtests that can be used in different combinations according to the child's need and the tester's orientation. Through a vast spectrum of subtests, the children's neuropsychological development is assessed in the five following areas: a) executive functions/attention, b) language, c) sensory-motor functions, d) visual-spatial processing, and e) memory and learning [10]. To measure and assess executive functions and attention, this study uses the NEPSY executive functions/attention subtests. The executive functions/attention subtests include tower, auditory attention and response set, statue, visual attention, design fluency, and tapping as well as knocking. The final coefficients for executive functions with due consideration to Cronbach alpha method were obtained as 0.81 and 0.89 for 4 to 5 and 5 to 6 year-old children, respectively.

Conner's parent rating scale: This questionnaire consists of 27 items for assessment of attention deficiency hyperactivity disorder symptoms. Scoring is based on the 4-item Likert scale (on a continuum from "never" to "mostly"). In the research by Shahabian et al. on standardization, the reliability and the Cronbach alpha coefficients for the total score were obtained as 0.58 and 0.73, respectively. Thus, the reliability of the total score was confirmed [11].

Wechsler's Intelligence Scale for Children: The Wechsler's intelligence scale for children (Version 4) [12] was implemented to assess the intelligence of the children under study. To assess the reliability of the Wechsler's scale results (Version 4), two methods were used. In the retest method, the final coefficients for all the subtests and intelligence quotients were calculated between 0.65 and 0.99, whereas in the Split-Half method, the same coefficients were found to be between 0.71 and 0.86, respectively [12]. This tool was utilized to assess the criterion reliability.

Basic motor ability test (BMAT): This test was prepared by Arnheim and Sinclair [13] to assess children between 4 and 12 years of age, and consists of 9 subscales used for the assessment of motor responses for control of small and large muscles, static and dynamic balance, eye-hand coordination, and flexibility. This test was standardized by Ganji [14] in 1997. The internal homogeneity of the test was reported as 0.89. In the present research, the internal homogeneity of the test was obtained from the Cronbach alpha method as 0.86.

Clinical Interviews: The structured clinical interview was conducted in accordance with the fourth mental disorder diagnostic and statistical guide (DSM-IV). Also, the test subject with DCD was diagnosed accordingly by a developmental-behavioral pediatrician (specializing on retarded children).

Training sessions: Training sessions on executive functioning of working memory based on Barkley's [3] Theory and Alizadeh's interventional package [15] were implemented in the present research. The concepts and strategies carried out during 10 individual training sessions are given in table 1.

Individual-case research, also referred to as single-subject experiment or time-series experiment, includes intensive research on a limited number of subjects individually or as a single group. In the present research, the multiple baseline design (MBD) was used. The MBD consists of two test situations A and B. In the general case, the first situation is the baseline. In the second situation, an interventional therapy is conducted and the dependent variable is evaluated.

The baseline position (control position), would measure the target's behavior before the performance of each therapeutic method. Therefore, in this research before the intervention was started, the parents and the trainer of the three test subjects had completed the Conners' questionnaire. Moreover, during these 4 sessions, no intervention took place. After that, 10 sessions of interventional therapy were conducted on test subjects individually in the presence of the in-charge psychologist in the center. In this research, the visual analysis was used for multiple baseline design of diagrams as well as the indices of trending, stability, percentage of non-overlapping data (PND), and percentage of overlapping data.

Results

The raw scores obtained from repeated measurements during baseline and interventional sessions are presented in figure 1.For MBD of data, first the diagram for each individual test subject was drawn. Then, using the median of the set of data obtained for the baseline and intervention positions, the mean line for data was drawn parallel to the X axis, and a stability envelope was placed on the median (Fig. 2-B). Stability envelope refers to two parallel lines, one drawn below and the other above the median line.

The distance and the amplitude between the two lines would show the degree of data dispersion or data variability. Upon implementation of the 80/20 criterion, if 80% of the data points lie within the 20% stability envelope, then the data would be stable [16]. For determining the data trending, the Split-Middle method was used and the envelope for the trending line was drawn according to the 80/20% criterion (Fig. 2A) .Upon drawing the median and trending lines as well as the envelope, the descriptive statistics indices such as the

mean value, and the inter-situational and intra-situational visual analysis indices such as level, PND, and tendency variations were calculated. PND indicates the non-overlap percentage of the points corresponding to the "baseline" and the "intervention" test situations, i.e., the number of data points that lie in position B outside the variation zone of A is calculated and then multiplied by 100. The degree of experimental control in single-case research is dependent on the level change between one situation to the other and the percentage of the non-overlapping data. In other words, there would be less experimental control on small changes of the dependent variable due to an intervention which coincides with a variable data path baseline position as compared with an intervention where the data path of the baseline is fixed. Moreover, the higher PND (or the lower POD) is situated as compared with its two neighboring situations, the more effective the intervention could be [16].

Based on the visual analysis of the test subject data diagram 1, the median line, the tendency line, and their corresponding stability envelope is obtained as follows (Fig. 2). Table 2 presents the results of intra-situational and inter-situational visual analysis for diagram 1, obtained for the test subject data submitted in visual analysis forms [16].

As shown in table 2, the mean attention scores decrease from 30 at the baseline to 26.2 at the intervention level, which is indicative of the test subject's reduced attention deficiency. Moreover, the PND index shows that the degree of overlap between baseline and intervention points was effective with a reliability of 80%. The median line, the trending line, and the corresponding stability envelope for test subject 2 are shown in figure 3. As shown in table 3, the mean attention scores decrease from 30.71 at the baseline to 24.8 at the intervention level, which is indicative of the test subject's reduced attention deficiency. Also, the PND index shows that the degree of overlap between baseline and intervention points was effective with a reliability of 70%.

The median line and the trending line indices, as well as their corresponding stability envelope for test subject 2 are shown in figure 4. As shown in table 4, the mean attention scores decrease from 31 at the baseline to 27 at the intervention level, which is indicative of the test subject's reduced attention deficiency. Also, the PND index shows that the degree of overlap between baseline and intervention points was effective with a reliability of 50%.

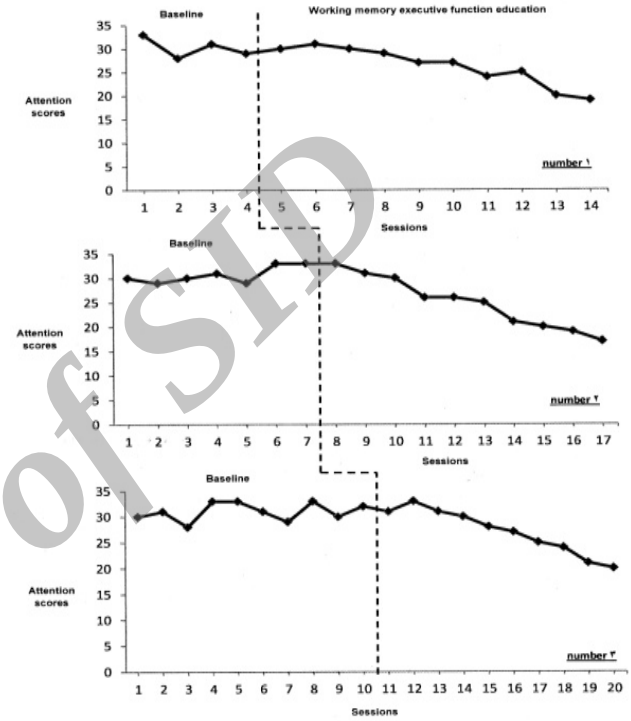
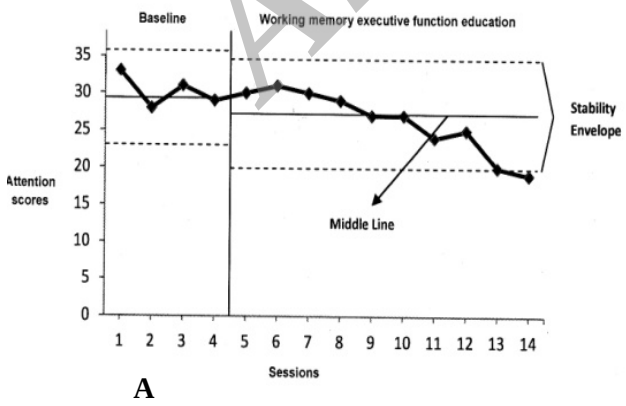
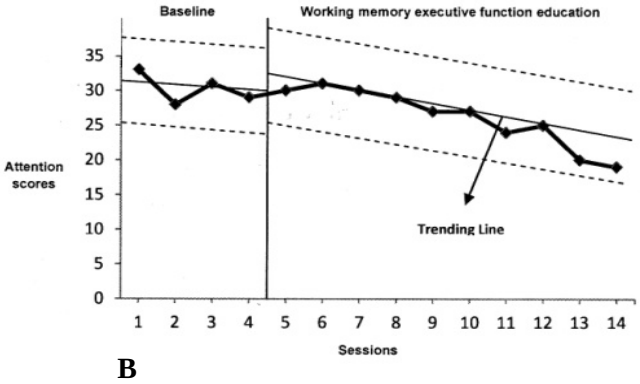


Figure 1. Influence of executive functions training on attention





Figur 2. Median line, trending line, and stability envelope for the test subject 1

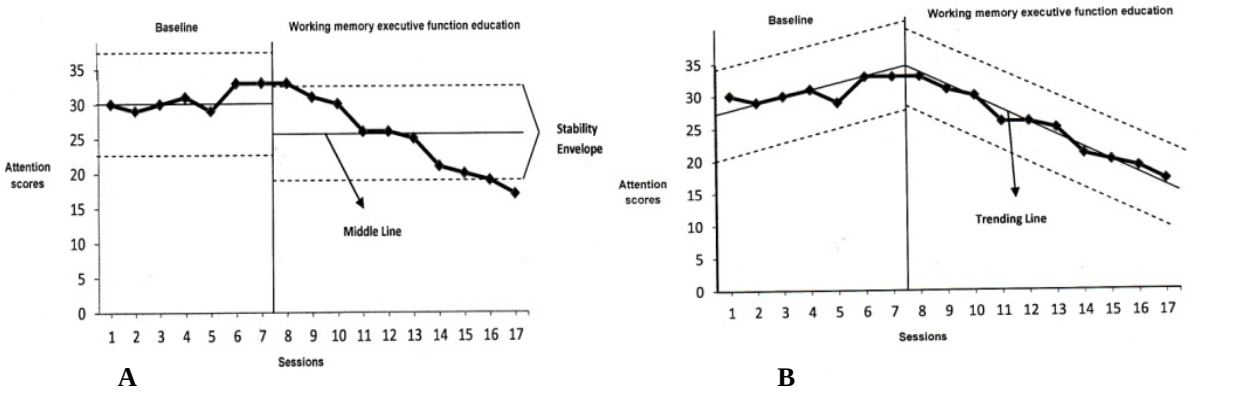


Figure 3. The median line, the trending line, and the corresponding stability envelope for test subject 2

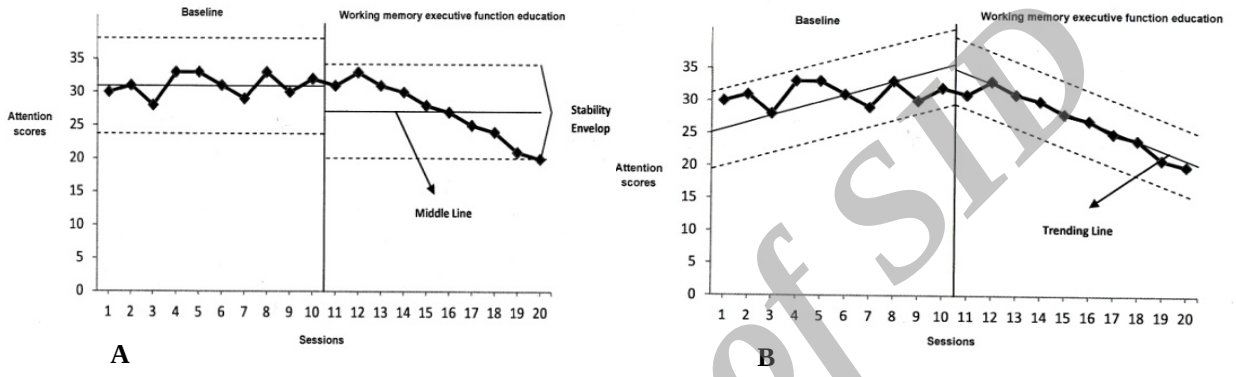


Figure 4. The median line, the trending line, and the corresponding stability envelope for test subject 3

Table 1. Training sessions of executive functions (working memory)

Session	Topics
1	The headings
2	Acquaintance/Establishing relations with the test subject and his/her parents; Definition
3	Reviewing the outcomes of the previous session assignment; Using incomplete pictures on the board and visual cards; New assignment for the next session.
4	Reviewing the outcomes of the previous session assignment; Using memory cards; Using Wechsler's Digit Span Test; New assignment for the next session
5	Reviewing the outcomes of the previous session assignment; Teaching memory games (using memory cards; using Wechsler's Digit Span Test); New assignment for the next session
6	Reviewing the outcomes of the previous session assignment; Word games and distinguishing words from the meaning conveyed by the cards collectively(aimed at enhancing retainment of data in the absence of an assignment pattern); Finally, the students were asked to take detailed notes of their room
7	Reviewing the outcomes of the previous session assignment; Playing with identity cards matched with numerical codes; New assignment for the next session
8	Reviewing the outcomes of the previous session assignment; Using color squares visual cards (aimed at improving students' attention); New assignment for the next session
9	Reviewing the outcomes of the previous session assignment; Teaching attention games (Wechsler's encoding and line drawing tests, Using attention enhancing cards; New assignment for the next session
10	Reviewing the outcomes of the previous session assignment; Presenting the results to parents.

Table 2. Intra-situational and inter-situational visual analysis variables for test subject 1

Intra-Situational				Inter-Situational		
1) Sequence of situations		A	B	1) Comparison of results		B/A
2) Duration of situations		4	10	2) Tendency variations	Change in direction	
3) Level	Median	29.5	27		Target-related effect	Positive
	Mean value	30	26.2		Change in stability	Stable/Stable
	Range of variation	29-33	19-30		Relative variation	31/31
	Stability envelope range of variation 20% from median	Stable	Stable	3) Change in level	Absolute variation	30/29
4) Change in level	Relative variation	28.5-31.5	24-30		Median variation	27/29.5
	Absolute variation	29-33	19-30		Mean variation	26.2/30
5) Trending	Direction	Descending	Descending	4) Overlap	PND	80%
	Stability	Stable	Stable		POD	20%

Table 3. Intra-situational and inter-situational visual analysis for test subject 2

Intra-Situational				Inter-Situational		
1) Sequence of situations		A	B	1) Comparison of results		B/A
2) Duration of situations		7	10	2) Tendency variations	Change in direction	
3) Level	Median	30	25.5		Target-related effect	Positive
	Mean value	30.71	24.8		Change in stability	Stable/Stable
	Range of variation	30-33	17-33		Relative variation	30/33
	Stability envelope range of variation 20% from median	Stable	Stable	3) Change in level	Absolute variation	33/33
4) Change in level	Relative variation	30-33	20-30		Median variation	25.5/30
	Absolute variation	20-33	17-30		Mean variation	24.8/30.71
5) Trending	Direction	Ascending	Descending	4) Overlap	PND	70%
	Stability	Stable	Stable		POD	30%

Table 4. Intra-situational and inter-situational visual analysis for test subject 3

Intra-Situational				Inter-Situational		
1) Sequence of situations		A	B	1) Comparison of results		B/A
2) Duration of situations		10	10	2) Tendency variations	Change in direction	
3) Level	Median	31	27.5		Target-related effect	Positive
	Mean value	31	27		Change in stability	Stable/Stable
	Range of variation	30-32	20-31		Relative variation	24/31.5
	Stability envelope range of variation 20% from median	Stable	Stable	3) Change in level	Absolute variation	31/32
4) Change in level	Relative variation	24-31	31-31		Median variation	27.5/31
	Absolute variation	30-32	20-31		Mean variation	27/31
5) Trending	Direction	Ascending	Descending	4) Overlap	PND	50%
	Stability	Stable	Stable		POD	50%

Discussion

The purpose of the present research was to reduce attention deficiency in children with DCD through executive functions training of their working memory. Results from analysis of diagrams obtained from the three test subjects all point to the fact that executive functions training effectively reduced the attention deficiency symptoms in the subjects. Our results are in agreement with the findings of Belger and Banich [9] who showed through their investigation that executive functions training (working memory, planning, and meta-cognitional skills) interventions can positively influence the mathematical performance of children with maths learning problems. They reported that children with disabilities regarding maths learning at primary school exhibited a significantly lower performance upon being subjected to executive functions measurements and tests. The above studies showed that deficiency in executive functions of children can also predict, to a great extent, their mathematical performance at school. These skills are internal processes children implement for learning, controlling and monitoring while participating in learning assignment programs. In their research conducted by Michl et al. [8] titled “development of cognitive skills in children with motor coordination deficiency”, the results showed after a year of relentless investigation that such children have fundamental difficulties in executive functions, particularly with regard to memory, inhibition and transactive functions.

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Authors’ Contributions
Farnoush Kavianpour: Data gathering and writing the article. Ali Raki: Statistical work. Dr. Mokhtar Malekpour: Article design, research idea, and contribution to the writing or the article.

Conflict of Interest
The authors declare no conflict of interest.

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