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Original Research

The effect of methylphenidate on speech patterns of children with attention deficit disorder

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Abstract

Background: This research is a field study dealing with practical aspects of speech with children who were diagnosed as having attention deficit hyperactivity disorder (ADHD). In the study speech patterns of children with ADHD were compared when they were under the influence of short-acting Methylphenidate to the time they were without short-acting Methylphenidate.

Methods: Neutral observers observed 26 children in the 3nd to 5th grade, mean age 10.34 years old, who were diagnosed as having ADHD. None of the participants had a history of speech-language deficits. The study was conducted in a randomized cross over design procedure. A 0.3 to 0.5 mg/kg of short-acting Methylphenidate was administered to all the participants. Their speech patterns were observed while they were under the influence of short-acting Methylphenidate and compared to the time when they were not under the influence of the medication.

Results: The results of the questionnaire, Conners' Teacher Rating Scale Revised-Long, showed the participants were assessed as having above the norm symptoms of ADHD by the questionnaire completed by their teacher. The observations showed less problematic speech behavior in the following three speech patterns pursuant to using short-acting Methylphenidate: voice intensity, rate of speaking, and interruption of someone else's speech. Pauses during the speech increased while the participants were under the influence of short-acting Methylphenidate. Improvement in the combination of three speech variables may make the difference between loud, fast, blurred, unclear, interrupting speech patterns that children with ADHD sometimes have without short-acting Methylphenidate as compared with the time when they behave appropriately in the classroom while they were administered a short-acting Methylphenidate.

Conclusion: The information that short-acting Methylphenidate had a positive influence on speech patterns of children with ADHD should be taken into account when considering prescribing short-acting Methylphenidate to children who were diagnosed as having ADHD.

INTRODUCTION

The present research dealt with pragmatic aspects of speech in children with Attention Deficit Hyperactivity Disorder (ADHD) as it appeared in their daily functioning. Tirosh and Cohen [1] claimed that 45% of the children who were diagnosed as ADHD had some language problems. Excessive speaking was one of the criteria used in the DSM-IV-TR [2] to diagnose ADHD. Exploring the differences in speech patterns of children with ADHD as compared to other children showed inconsistent results of speech development and speech pathology among ADHD. Children with ADHD tended to have delayed onset of talking in early-childhood [3,4]. In contrast, Barkley, DePaul, and McMurray [5] did not find such differences, while others [6] found that children with ADHD produced

good oral narratives skill (in a task requiring the child tell a specific story) regardless of other cognitive processes. They concluded their study about the oral narrative production of ADHD by saying, "Participants in this study produced good oral narratives, implying that their cognitive processing deficits did not appear to affect their narrative production significantly however observations indicated less than adequate planning and attention to the task" (Moonsamy & Jordan, p. 333). More consistent were the findings that children with ADHD had difficulties in expressive language rather than in receptive language [5,7]. Hurks et al [8] found that children with ADHD had a greater lag in generating words at the beginning of the task as compared to non-disabled children or to children with other psychiatric disorders. Another study found deficits in verbal fluency (or letter fluency) among children with ADHD; it was measured by asking the child to name as many words of a particular category as possible, within one-minute [9]. Similar findings with the same instruments were found by other researchers [10], who summarized a meta-analysis of 22 studies; and by Clark, Prior, and Kinsella [11]

Several studies explored speaking styles and hearing among children with ADHD under the influence of short-acting Methylphenidate (brand name Ritalin). Benedetto and Elizabeth [12], and Chang [13] found in controlled laboratory studies that Ritalin allowed children with ADHD to control better their behavior and speech patterns. Three different studies showed improvement on the Central Auditory Processing (CAP) test performance in children with ADHD, children with Central Auditory Processing difficulties, or children with both disorders, under the effects of Ritalin [14,15,16]. In contrast to these findings, Tillery [17], Tillery, Katz and Keller [18] found that children with ADHD had improved auditory sustained attention under the influence of Ritalin, although, auditory dysfunction was not eliminated as compared to the time they were administered a placebo. It was stated by others that Ritalin did not have a significant influence on the speaking style of children with ADHD, although it did have positive results on reduction of inattention and other behavioral problems [19]. It was clear that findings in this area were inconsistent and research in this field is still insufficient. The purpose of the present research was to expand the knowledge in this area.

The present research compared speech patterns of children with ADHD, who were under the influence of short-acting Methylphenidate as compared to the same children when they were not under the influence of short-acting Methylphenidate. The effect of the time of the day (first lesson of the day vs. last lesson of the day) upon speech patterns was also assessed. In the present study, there were four dependent variables: speech intensity, pauses while speaking, rate of speaking, and interruptions of someone else's speaking. The influence of the medication and the time of the day were the independent variables. These variables were selected because they appear to be important behavioral domains of speech pragmatics that can be assessed in a field study. The null hypothesis was that children with ADHD would have similar speech patterns with no short-acting Methylphenidate as compared to the time they were administered a short-acting Methylphenidate, and a similar functioning in the early hours of the day as compared to the end of the school day.

None of the authors had any interests that might be interpreted as influencing the research. The ethical standards of Yezreel Valley College were followed in the conduct of the study. All the parents of the participants signed an informed consent indicating their agreement to participate in the study.

METHOD

Participants

Twenty-six children participated in the study, 18 boys and 8 girls, with a mean age of 10.34 (SD = 1.93). All participants were in the 3nd to 5th grade and lived with their parents in small towns or villages in Northern Israel. Academically the participants were considered 'average'. None of the participants had a history of speech-language deficits. All the participants were diagnosed as having ADHD by a child psychiatrist who used DSM-IV-TR criteria [2]. In addition, the Conners' Teacher Rating Scale-Revised**,** Long rating scale (CTRS-R: L [20]) was administered to the teachers of all participants before the study started. The group of participants in the study was considered to have moderately high symptoms of ADHD. As it is often the case with children who were diagnosed as ADHD, there were co-morbidity of various problems, as seen in the results of the Conners' Teacher Rating Scale-Revised**:** Long (CTRS-R: L [20]) in table 1. Still, the main diagnosis of the participants in this study was ADHD. The diagnoses of the children were based on interviews with the parents, a meeting of the psychiatrist with the child, and a rating scale answered by the teacher. All participants received 0.3 to 0.5 mg/kg of short-acting Methylphenidate, which was based on their weight and under the supervision of the psychiatrist who administered the medications. This dosage was chosen as it was considered the best effective dosage for cognitive functioning [21]. The class teacher was responsible for the administration of the short-acting Methylphenidate pill before each school day or in the middle of the day, depending on the research condition to be described later.

Instruments

To assess the level of difficulties of each child, the teacher filled out the questionnaire, Conners' Teacher Rating Scale-Revised: Long (CTRS-R: L [20]). This version was translated and adapted for use in Israel [22]. The questionnaire had 59 items and fifteen behavioral measures assessing difficulties of children with ADHD ages 3 to 17 years old, as described by the scale's manual.

The assessment of speech patterns of the participants was accomplished by direct observation of two observers; both observed the same child at the same time in the classroom. Each child was observed twice under no medication condition and under the influence of the medication. The observation lasted the entire class period of 50 minutes. The score on each variable was based on the total counts of all the occurrences of the given behavior during the entire class. During the observation four speech variables were assessed independently on a four-point scale. The speech variables used in the study were:

A. Speech intensity: In this variable, the intensity of speech was assessed based on observation. The following four levels were rated based on the observer's estimation: (1) low intensity speech, (2) medium intensity speech, (3) strong intensity speech, and (4) shouting.

B. Pauses while speaking: This variable assessed the fluency of speech in the following four levels based on the observer's estimation: (1) many pauses during speaking, (2) a few pauses during speaking, (3) very few pauses during speaking, and (4) no pauses during speaking.

C. Rate of speaking: In this variable, the speed of speaking was assessed by the following four levels according to the observer's estimation: (1) slow speaking, (2) average speaking speed, (3) fast speaking, and (4) very fast speaking speed.

D. Interruptions by the participant of someone else's speaking: This variable was assessed when the student spoke while another student spoke, and without the permission of the teacher, it was recorded throughout the lesson observed. This measure was assessed according to the following ratings: (1) no interruptions, (2) 1-4 interruptions during the lesson, (3) 5-9 interruptions during the lesson, and (4) 10 or more interruptions during the lesson.

All observations of the different conditions were made in a similar manner, which meant, observing the same children and in similar lessons of direct instruction. Each child was observed when he or she received permission to speak. Observation of interruptions of someone else's speaking was made during the entire lesson. Each observer assessed the behavior individually. The assessments of speech patterns were rated on a four-level scale. The average of the two observers determined the final measure for each student. The observers did not know the hypothesis of the study and were naïve with respect to treatment condition (drug vs. placebo). Two teams of two observers each were used in the study. In one of the teams, the correlation of the interobserver agreement was 0.92, while in the second team; the correlation of the interobserver agreement was 0.94. In addition, the classroom teacher completed the Conners' Teacher Rating Scale-Revised**:** Long (CTRS-R: L [20]) rating scale prior to the beginning of the study.

Procedure

The study was conducted as a randomized cross-over design procedure in order to disentangle possible time-related changes because of differences in the time that medications were administered. Participants were assigned randomly to each group, (morning or afternoon, and medication or no medication). The study was done in regular classes of children when two observers entered each lesson and observed the speech patterns of each student for the length of one lesson each time (50 minutes). The observers were college students who received prior training in a class of behavior modification. The teacher informed her children that visitors would come to observe their lesson. Before the observed lesson started, the teacher was asked to allow the specific observed student to speak during the class more often than usual. This was done in two ways, the teacher called on the students, and/or responded to their hand-raising more often. The observers assessed only the formal speaking of the children, which meant, only when the child received the permission to speak. The observations were made when each child was in one of the following two 'medication' conditions: **(1) No medication:** in which they did not take medication before the first lesson of the day or when the effect of short-acting Methylphenidate taken in the morning weakened during in the last lesson of the day; **(2) short-acting Methylphenidate:** in which short-acting Methylphenidate was administered ninety minutes before observation of the first lesson, or when short-acting Methylphenidate was administered ninety minutes before the observed last lesson of the day. Two conditions were used in the study **(1) Early observations:** observations were made during the first lesson of the day without taking or after taking the medication ninety minutes before the lesson started. **(2) Late observations:** observations were made either in the last lesson of the day when the child was administered short-acting Methylphenidate ninety minutes before the first lesson of the day and by the

time of the observation, the effect of the short-acting Methylphenidate had weakened, or when the child was administered short-acting Methylphenidate in the middle of the day about ninety minutes before the last lesson. Half of the participants were in the 'short-acting Methylphenidate-early observation condition' while the second half was in the 'short-acting Methylphenidate-late observation condition.'

RESULTS

A comparison of gender effect showed no statistically significant differences in the four speech patterns used in the study**.** Given these findings allowed researchers to continue the statistical procedures without regard to gender.

The initial assessment was an evaluation of the ADHD level of each child as seen and evaluated by the teachers. This procedure was done in order to confirm the diagnosis of ADHD of the participants. In most sub-scales (7 out of 13 scales, compared to male norms and 12 out of 13 compared to female norms) of the Conners' Teacher Rating Scale-Revised: Long (CTRS-R: L [20]), participants in the study had a higher T-score than 65 which was considered a high score. These results can be seen in Table 1.

The results of speech patterns were based on subjective assessment of the observers, which could be described as an ordinal scale. Therefore, a nonparametric statistic was used to make the calculation. The Mann-Whitney U Test was used to compare the speech patterns with and without short-acting Methylphenidate. The second part of the study was to check if there was an effect of the time of the day. Speech patterns in the first lesson of the day were compared to the speech patterns in the last lesson of the day regardless of the status of medication (with or without short-acting Methylphenidate). The results showed that in two variables there were significant changes in the quality of speech patterns. There were more pauses while speaking in the last lesson (Mann Whitney $U = 89.50$, $p = 0.001$) and fewer interruptions of someone else's speech in the last lesson (Mann-Whitney $U = 180.50$, $p = 0.008$). No changes were observed in the effect of the time of the day in the other two variables of speech intensity and rate of speaking. These results are shown in Table 2.

Table 1. Means, Standard Deviations and T-Scores of the Conners' Teacher Rating Scale-Revised: Long (CTRS-R: L [20]) of All the Participants (N = 26) in Comparison to the Norm Group.

Variable	Raw Score	SD	T-Score for Boys	T-Score for Girls
Oppositional	7.20	4.61	69	71
Cognitive Problems	13.70	3.77	63	70
Hyperactivity	11.40	6.15	66	90
Anxiety-Shy	9.50	3.89	75	80
Perfectionism	8.00	2.31	67	62
Social Problems	7.10	3.00	68	76
Conners' Global Index	19.80	6.48	64	79
Restlessness-Impulsive	9.60	3.60	63	78
Emotional Instability	5.70	3.30	72	87
ADHD Index	15.30	6.09	68	72
DSM-IV Symptoms Inattention	15.90	5.00	62	73
DSM-IV Hyperactivity.Impulsivity	12.20	5.51	62	83
DSM-IV Total	28.10	10.07	63	80
DSM-IV Inattention Raw Score	6.70	2.26		
DSM-IV Hyper/Impuls. Raw Score	4.20	3.01		
DSM-IV Total Raw Score	10.90	4.91		

Table 2. Means, Standard Deviation, and Mann-Whitney U of Various Speech Patterns of Taking the short-acting Methylphenidate in the Morning as compared to the time when the short-acting Methylphenidate was taken later in the day (N = 26).

	Speech Patterns at Different Lessons							
	The First Lesson of the Day		The Last Lesson of the Day					
	M	SD	M	SD	M-W U	z	p	Effect Size
Speech Intensity*	2.53	1.05	2.00	0.81	230.50	1.71	0.090	0.34
Pauses While Speaking*	2.68	0.83	1.60	0.62	89.50	4.40	0.001	0.86
Rate of Speaking[c]	2.38	0.80	2.10	0.66	255.50	1.24	0.220	0.24
Interruptions of Speech[d]	2.47	0.96	1.75	0.75	180.50	2.66	0.008	0.52

Note: M-W U = Mann-Whitney U; a = Higher score meant higher intensity; b = Lower score meant more pauses; c = Higher score meant faster speaking; d = Higher scores meant more interruptions.

Table 3. Means, Standard Deviation, and Mann-Whitney U of Various Speech Patterns under the Influence of short-acting Methylphenidate as compared to the when Ritalin was not taken (N = 26).

	Methylphenidate							
Variable/Condition	With short-acting		Without short-acting					
	M	SD	M	SD	M-W U	z	p	Effect Size
Speech Intensity*	1.81	0.88	2.85	0.81	126.50	3.92	0.001	0.77
Pauses while Speaking*	1.85	0.62	2.67	1.00	179.50	2.94	0.003	0.58
Rate of Speaking[c]	1.89	0.61	2.57	0.95	137.00	3.74	0.001	0.72
Interruptions of Speech[4]	1.81	0.79	2.58	0.95	185.00	2.85	0.005	0.56

Note: M-W U = Mann-Whitney U; a = Higher score meant higher intensity; b = Lower score meant more pauses; c = Higher score meant faster speaking; d = Higher scores meant more interruptions.

The most important aspect of the study was the comparison of speech patterns under the influence of short-acting Methylphenidate as compared to the time when the participants were without short-acting Methylphenidate. The results showed a significant improvement in speech patterns in three out of four variables used in the study. The intensity of speech was lower under the influence of short-acting Methylphenidate (Mann-Whitney U = 126.50, $\underline{p}$ = .001). The rate of speaking was slower under the influence of short-acting Methylphenidate (Mann-Whitney U = 137.00, $\underline{p}$ = .001). There were fewer interruptions of someone else's speaking under the influence of short-acting Methylphenidate (Mann-Whitney U = 185.00, $\underline{p}$ = .005). In one variable, there was a significant better performance when the children were not under the influence of short-acting Methylphenidate. There were more pauses while speaking under the influence of short-acting Methylphenidate (Mann-Whitney U = 179.50, $\underline{p}$ = .003). These results are found in table number 3.

The results of the study reported only to the main effects of the 'time of the day' and the 'medication condition,' as no interactions were found between these variables in all four measures used in the study.

DISCUSSION

In the results of the present study, the null hypothesis was rejected in three of the four-research variables: speech intensity, rate of speaking, and interruptions of someone else's speaking. In one research variable, 'pauses while speaking,' the null hypothesis was failed to be rejected. These findings showed that short-acting Methylphenidate had a positive effect on three of the four speech patterns measured. Similar results were found by Benedetto and Elizabeth [12] and Chang [13] who found in controlled laboratory studies that short-acting Methylphenidate allowed children with ADHD to control better their behavior speech patterns. Others [23], described the effect of Methylphenidate by stating that "We suggested that Methylphenidate change the resonance of speech production by lowering the fundamental frequency. Thus, Methylphenidate would maintain regularization of loudness by controlling motor speed centrally" (Congologlu, et al p. 365). Still, other investigations did not find a positive effect of short-acting Methylphenidate on speaking styles of children with ADHD.

Comparison of speech patterns influenced by the time of the day regardless of whether the participants were

under the influence of short-acting Methylphenidate or not, showed that in the last lesson of the day, there were more pauses and fewer interruptions of someone else's speaking as compared to the first lesson of the day. Based on these results it was assumed that becoming tired toward the end of the day caused more pauses which were an undesirable change in speech patterns. However, there were fewer interruptions of someone else's speech, which was a positive change in the speech pattern. Based on these findings no clear conclusion could be made regarding the effect of the time of the day upon the speech pattern of the sample in the present research.

The results of the present study showed clearly that short-acting Methylphenidate had a positive effect on the speech patterns in three of four variables used in the study of children with ADHD. Changes in speech patterns were positive since under the influence of short-acting Methylphenidate, the rate of speaking is slower, the intensity of speech is lower, and there were fewer interruptions of someone else. Only in one variable, pauses in speaking, the performance of children with ADHD deteriorated. Possible explanations for these findings are that the changes observed in the speech patterns reflect the effect of the short-acting Methylphenidate on the decline, mainly in the components of impulsiveness in ADHD. There was no apparent reason why there were fewer pauses while speaking when the participants were in a 'non-medication condition.' Nevertheless, the combination of these three variables might make the difference between loud, fast, blurred, unclear, and interrupting others behaviors that children with ADHD sometimes had, as compared to the way children without ADHD behave appropriately in the classroom. The essential point here was that the results were found in a field study in the natural environment where the participants attend school. This confirmed initial assumption that short-acting Methylphenidate has a significant positive effect on the speech pattern of children with ADHD.

Practical application of the study could be the possible use of short-acting Methylphenidate for children with ADHD in the case of speech difficulties regardless if there are other behavioral or cognitive difficulties. Knowing that short-acting Methylphenidate helps speech patterns of children with ADHD, this could be an important factor in the decision to prescribe the medication. The authors of the present paper were not aware of cases when children with ADHD were prescribed short-acting Methylphenidate only because of speech problems. Still, this is an idea that could be considered in a few cases when such approach can be appropriate. Still, should remember that Methylphenidate may have side effects affecting speech. It was suggested that although rare, there is a possibility that disturbances in voice quality and hoarseness is related to Methylphenidate influencing the central and sympathetic nervous systems [24,25].

Limitations of the study indicated that this was a field study where tools of assessment were not as well controlled and accurate as could be in a laboratory study using objective measures using computerized programs and electronic devices. It is important to continue research on speech patterns of children with ADHD. In future studies, it is possible to use recording devices such as a tape recorder, video recording, and acoustic measures scoring via Praat to determine the speech intensity, pauses, and rate of speech. This procedure might allow results that are more accurate. Larger sample with a non-ADHD control group may increase our knowledge.

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