Fractionated Reaction Time in Attention Deficit and Hyperactivity Disorder Children

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Abstract

Simple reaction time (RT) was divided into cognitive and motor time to more closely determine the development changes in cognitive processing time. Motor time (MT) and cognitive time (pre-MT) were determined using Electromyography (EMG) to fractionate RT.

Twenty-eight children were divided into two groups: ADHD (n=14) and non-ADHD (n=14) groups completed a minimum of 10 practice and 10 test trials by lifting the index finger from a depressed button. The result of this study indicated that significant differences between the two groups and ages were found. The most remarkable differences in this study were that children with ADHD spent more time than non-ADHD children on pre-MT in both ages.

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سرعة رد الفعل المجزئة لأطفال ذوي عجز الانتباه والنشاط الزائد

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الملخص

هدفت هذه الدراسة إلى التعرف إلى سرعة رد الفعل بجزئية مرحلة التفكير ومرحلة اتخاذ القرار. حيث تم استخدام إشارة (EMG) لتحديد تجزئة سرعة رد الفعل. بلغ حجم عينة الدراسة (٢٨) طفلاً قسموا إلى مجموعتين: مجموعة أطفال النشاط الزائد وعجز الانتباه (١٤ طفلاً وطفلة) ومجموعة الأطفال الأصحاء (١٤ طفلاً وطفلة). أظهرت نتيجة الدراسة وجود فروق ذات دلالة إحصائية بين المجموعتين ، حيث كان الاختلاف وبين فئتي العمر واضحاً في مرحلة التفكير عند أطفال النشاط الزائد وعجز الانتباه، إذ اخذوا وقتاً أطول للتفكير باتخاذ القرار في المرحلتين العمريتين (٨ و ٩). وبناءً على هذه النتائج توصي الدراسة بإجراء دراسة مشابهة بالتركيز على مرحلة التفكير كجزء من سرعة رد الفعل.

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Introduction

The defining feature of Attention-deficit / Hyperactivity Disorder (ADHD) is a behavior that seems "inattentive, hyperactive, and impulsive to an extent that is unwarranted for the person's developmental age and is a significant hindrance to their social and educational success" (Reason, 1999, p. 85). ADHD is one of the most thoroughly researched childhood psychiatric disorders (Barkley, 1991). Between 3% (American Psychiatric Association, 1987 and 20% of the total school-age population of the United States has been diagnosed with ADHD. This estimation represents a significant number of people influenced by a disorder that may continue into adulthood (Weiss & Hechtman, 1993).

ADHD occurs more frequently in males than in females; the ratio ranges from 4:1 to 9:1, depending on the setting (Sherrill, 1998). ADHD represents a heterogeneous population who display considerable variation in the degree of their symptoms, in the pervasiveness of those symptoms, and in the extent to which other disorders occur in association with it (Barkley, 1998).

Reaction time (RT) is "a measure of the time delay from the arrival of a suddenly presented stimulus to the beginning of some predetermined motor response". RT represents an important aspect of human motor performance, not only in physical education and sport, but also in daily living (Grouios, 1989).

RT is the sum of a number of processing times, each of which is consumed by a processing stage that is involved in the translation of a stimulus into a response. These stages include: a) sensory encoding, b) stimulus storage, c) perceptual encoding, d) memory comparison, e) response selection, and f) initiation of the action that constitutes the response (Mclelland, 1979; Grice, Nullmeyer, & Spiker 1982). The demands on all stages are supposedly reflected in the RT, from the arrival of the stimulus until the response (Sanders, 1980). The first three of these stages are believed to be as short as a few milliseconds. The last of the six stages is also believed to be short for simple hand actions requiring little strength, such as pressing a button (Marteniuk, 1976). The greatest part of RT, however, is assumed to be taken up by the fourth and fifth stages, of memory comparison and response selection (Welford, 1980).

Speed of reaction is dependent on three principal classes of variables: (a) stimulus variables, which are inherent in the stimulus event itself (e.g., duration, intensity, magnitude); (b) response variables which include those variables that relate to the type and characteristics of the response required (e.g., simple RT, choice RT, and discriminative or disjunctive RT); and (c) the final class of variables, which have been of interest to researchers, are those which are concerned with the individual performer himself or herself, the subjective variables (e.g., arousal level, intelligence, gender) (Carron, 1971). One of the defining features of good motor coordination is good timing. Precise timing as is required, for example, in musical performance implies both a small constant error and limited variability (Geuze & Kalverboer, 1994).

Electromyography (EMG) is a technique used to identify relative levels of activation of different muscles or parts of a muscle. EMG was explored and refined as a tool for studying muscle behavior by Basmajian (1978), who is considered the "father" of EMG. The EMG technique has been widely used throughout the last decades to evaluate and interpret human muscle performance (Stefanidis, Vamvakoudis, Patikas, Bassa, Kotzamanidis, & Giannakos, 2001). This study used EMG to separately measure the pre-motor time (pre-MT) and motor time (MT) in each trial. EMG of the responding muscle allows us to determine the time the electrical activity is first activated on the motor neuron that leads to a response, which occurs after the initiation of the motor process. (Luce, 1986). Increasing scientific attention to the movement of the fingers has emerged. If a single finger moves, the "antagonist" must remain active to immobilize the other fingers. However, if the other fingers are held immobile by an observer, there is no activity in the antagonist muscle (Basmajian & Deluca, 1985). Deluca, Lefever, McCue, and Xenakis (1982) verified, in human muscles, that when the force output of a muscle is voluntarily decreased, motor units are recruited in the opposite order in which they were recruited.

In an early study addressing the developmental aspect of processing

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speed,.Thomas, Gallagher, and Puris (1981) found that as age increased RT decreased, with males having more rapid RT than females for subjects of five age levels ranging from 7 to 20 years of age. In children RT shows a linear decrease with increased age. The cognitive literature supports the notion that younger children generally have poor movement plans (Thomas, 1980).

Research has confirmed the overlap between the temporal aspect of language production and hand movements (Bellman & Walter, 1985. Kail (1991) argued that children's speed of processing is systematically related to that of adults. Kail compiled the findings of numerous studies comparing the processing speed of adults and children and found that under a broad range of circumstances and conditions, the RT of children, although consistently slower than that of adults, could be expressed as a direct function of that of adults. Kail interpreted this as an indication that a developmental factor is responsible for the change in RT from childhood to adulthood.

Limited empirical data addresses the movement of children with ADHD. Descriptive levels of research may provide a more thorough understanding of these children by providing profiles of fitness and fundamental gross motor performance (Harvey & Reid, 1997). Children with ADHD frequently display disparities in performing gross and fine motor tasks (Porter & Omizo, 1984; Wender, 1987). ADHD Children tended to perform poorly on tests measuring proficiency in visual motor tasks (Alexander, 1990). Harvey & Reid (1997) studied 19 Children with ADHD, nearly all of whom were on stimulant medication. They found that "as a group, performance of the children in fitness and fundamental gross motor skills was below average when compared to the norms of children of similar age and gender". Beyer (1994) recommended the creation of such motor profiles, and Churton (1989) recommended descriptive studies that document major motor milestones.

Purpose of the Study

The purpose of this study was two-fold:

1- To discover if the RT of small motor skills tasks are affected by ADHD in children.

2- To determine whether there are significant differences in the pre-MT and MT as separate parts of RT.

Questions of the Study

The study was designed to answer the following three questions:

1- What is the difference in the RT's of children diagnosed with ADHD as compared with children without ADHD using EMG signal?

2- Were there significant differences in the two groups RT?

3- Were there significant differences based on age and gender of the two groups?

Significance of the Study

There has been little research focusing on the RT of children diagnosed with ADHD. Furthermore, there has been no research that separates RT into MT and pre-MT. Considering the prevalence of children with ADHD, it is important to understand all of the effect of the condition. This study can be used by researchers to clarify the physical manifestations of ADHD in order to enhance the quality of treatment for children with ADHD.

Research Methodology

Subjects

Twenty-eight children participated in the experiment. They were divided into two groups: an ADHD group aged 8 to 9 years (eight males and six females, M = 8.6 years, SD = 0.5), and a non-ADHD group aged 8 to 9 years (eight males and six females, M = 8.6 years, SD = 0.5) (see table 1). Participants were recruited on a voluntary basis and informed consent by parents was provided to the experimenter. Further, it should be noted that ADHD children with medication were asked by the researcher to be off medication on the day of testing.

Table 1
Descriptive data for the two groups, ADHD and non-ADHD

Group	N	Age		Gender	
		Mean	SD	MaleS	femaleS
ADHD	14	8.6	0 .5	8	6
Non-ADHD	14	8.6	0 .5	8	6
Total	28	8.6	0 .5	16	12

Procedure

During testing, each child was asked to sit comfortably on an adjustable chair. Two electrodes were attached to the child's forearm with an inter-electrode distance of 2 cm, and a third one was attached to the child's upper arm. These were held in place with a clear gel and small pieces of tape. Before the electrode placement, the skin surface was cleaned. The child sat facing the Reaction Time Board, which was on the desk. When the child was ready, a button buzzed and lit. The child then depressed the button with his/her finger. The objective was to do this as fast as possible. The experimenter measured how long this took while recording the impulses from the nerves in the child's arm using EMG. Typically, 20 practice trials were completed for each child, the average for the last 10 practice trials being used as a motivator. Before each trial,the participants were given a verbal preparatory signal; "ready". The signal occurred at random times from 30 msec. to 50 msec. later.The children were reinforced with whistles and claps when the RT was faster than the 10-trial average. The whole time of the experiment was 25-30 minutes. Data recorded by the computer included the EMG signal.

Design and Data Analysis

A 2 (age) x 2 (group) univariate analysis of variance was used in this study. 20 practice trials were completed for each child. The first ten practice trials were given to the participants to make sure they understood the task. Using the last ten trials, the RT mean scores, the pre MT mean scores, and the MT mean scores were calculated.

The statistical analysis was set up in a separate 2 (age) x 2 (group) univariate analysis of variance (ANOVA) using RT scores as a dependent variable and age x group as independent variables.

Results

The RT mean score for each of the RT tests were calculated for all participants (see Table 2). Table 2 also presents the means and the standard deviations for pre-MT (for non-ADHD 8-year-olds, M = 216.18 ms., SD = 22.85; for 9-year-olds, M = 180.70 ms., SD = 12.13; for ADHD 8-year-olds, M = 265.75 ms., SD = 46.42; for 9-year-olds, M = 199.97 ms., SD = 35.92) and the means and standard deviations for MT (for non-ADHD 8-year-olds, M = 70.72 ms., SD = 7.60; for 9-year-olds, M = 61.63 ms., SD = 12.17; for ADHD 8-year-olds, M = 63.36 ms., SD = 15.65; for 9-year-olds, M = 70.47 ms., SD = 15.68). It was apparent that, on average, the study sample scores for the RT, pre-MT for both ages and groups extended beyond what was predicted. The children with ADHD spent more time than the non-ADHD on pre-MT in both ages (see figure 1). These data showed that the children with ADHD take longer than non-ADHD children to make a decision to do the task that requires a rapid response.

Using RT as the dependent variable, the simple one-way analysis of variance (ANOVA) (see Table 3) indicated that gender was of no significant effect. Therefore, gender as a variable was not calculated. The group main effect univariate analysis of variance (ANOVA) $F(1,24) = 8.26$ (see table 4) showed decreasing RTs in the non-ADHD group (for the non-ADHD group, $M = 261.43$ ms., $SD = 30.88$; for ADHD group, $M = 295.58$ ms., $SD = 48.71$). The age main effect univariate analysis of variance (ANOVA) $F(1,24) = 17.81$, $P = .0001$ showed decreasing RTs as age increased (for non-ADHD 8-year-olds, $M = 286.90$ ms., $SD = 22.73$; for 9-year-olds, $M = 242.33$ ms., $SD = 20.71$; for ADHD 8-year-olds, $M = 329.11$ ms., $SD = 48.27$; for 9-year-olds, $M = 270.44$ ms., $SD = 32.49$) (see table 2).

Univariate analysis of variance (ANOVA) was conducted for RT test to test for group effects and age effects. The sample was divided into two groups, the ADHD group and the non-ADHD group, and two ages within each group: 8-year-olds, and 9-years-olds. Group and age were found to have a significant effect on RT test (see table 4). These comparisons revealed a significant difference between the two groups and ages. These data offer considerable evidence that RT increases linearly in the two groups with increased age. The longer pre-MT of children with ADHD have been interpreted to be the result of the brain's ability to process information which means that ADHD children's responses are slower than those of non-ADHD children. These results support the literature which suggests that children with ADHD may be inefficient movers (Beyer, 1994; Moffit, 1990).

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Table 2
Means and standard deviations for RT, pre-MT, and MT for ADHD and Non-ADHD group with their ages

Group Age		M (RT)	SD (RT)	M (Pre-MT)	SD (Pre-MT)	M (MT)	SD (MT)	N
ADHD	8	329.11	48.27	265.75	46.42	63.36	15.65	6
	9	270.44	32.49	199.97	35.92	70.47	15.68	8
	Total	295.58	48.71	228.16	51.62	67.42	15.49	14
Non-ADHD	8	286.90	22.73	216.18	22.85	70.72	7.60	6
	9	242.33	20.71	180.70	12.13	61.63	12.17	8
	Total	261.43	30.88	195.91	24.74	65.52	11.12	14
Total	8	308.00	42.19	240.97	43.44	67.04	12.34	12
	9	256.39	30.06	190.34	27.74	66.05	14.31	16
	Total	278.51	43.63	212.04	42.98	66.47	13.27	28

RT = Reaction time, Pre-MT = Pre- Motor Time, MT = Motor Time

Table 3
One-way analysis of variance for gender and reaction time

Source	df	Sum of Squares	Mean Squares	F	P
Between Groups	1	22.441	22.441	0.011	0.916
Within Groups	26	51379.843	1976.148		
Total	27	51402.284			

Table 4
Univeriate analysis of variance for group and age with reaction time

Source	df	Sum of squares	Mean squares	F	P
Group	1	8477.288	8477.288	8.26	0.008
Age	1	18270.006	18270.006	17.805	0.000
Group X Age	1	340.504	340.504	0.332	0.570
Error	24	24626.319	1026.097		
Total	27				

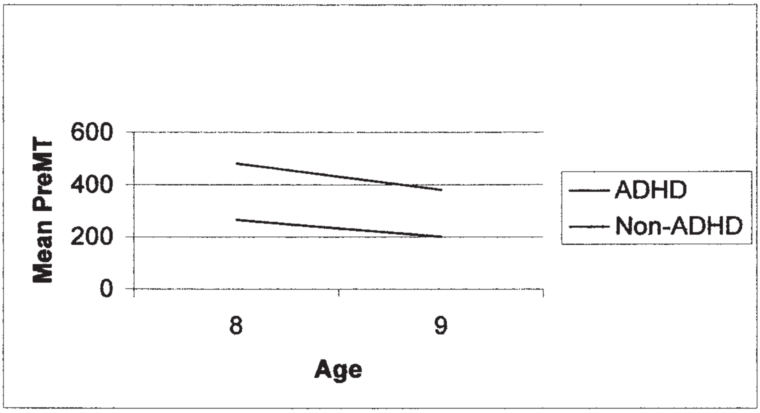

Figure 1: Mean Pre-MT at each age level for ADHD and non -ADHD groups

Discussion

This study compared children with ADHD and non-ADHD children aged 8 and 9 who differed in their RT. When this was done, the RT of children with ADHD in this study was found to be longer than the RT of non-ADHD children. This means that children with ADHD are slower than non-ADHD children in cognitive decisions during a task that requires a rapid response, and this result is consistent with the prediction.

The findings of this study indicated consistent differences in cognitive processing and whether these differences were related to ability and age differences. Their results revealed that processing speed was related to mental ability level, and further that processing speed was systematically related to age. According to the comparison between an ADHD group and a non-ADHD group, the findings of this study are consistent with the findings by Alexander (1990) that ADHD children tended to perform slower on tests measuring proficiency in visual motor tasks. Also, Harvey & Reid (1997) found that "as a group, performance of the children in fitness and fundamental gross motor skills was below average when compared to the normal children of similar age and gender".

The most remarkable differences in this study were that children with ADHD spent more time than non-ADHD children on pre-MT in both ages. Further, the results indicated that children with ADHD took longer than non-ADHD children to make a decision to do the task that requires a rapid response.

The longer pre-MT's of children with ADHD have been interpreted to be the result of the brain's ability to process information, which means that ADHD children's responses are slower than those of non-ADHD children. Further, the RT test used in this study may appear to be relative to those typically used in previous literature, which suggests that children with ADHD may be inefficient movers (Beyer, 1994; Moffit, 1990). The results presented thus far contribute considerable support that the responses of children with ADHD are slower than those of non-ADHD children.

Conclusion

This study found that the reaction time of children with ADHD was greater than children without ADHD. In addition, when Pre-MT was measured separately, it was also found to be longer in ADHD children than in non-ADHD children. Therefore, when presented with a stimulus that demands a rapid response, children with ADHD respond at a slower rate. While these results are significant, further research regarding Pre-MT as a part of RT is recommended.

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