Effects of psycho-educational training and stimulant medication on visual perceptual skills in children with attention deficit hyperactivity disorder

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Abstract: Attention deficit hyperactivity disorder (ADHD) is treated with stimulants and psycho-educational remedial programs despite limited literature support for the latter. This study aimed to examine changes in a "Test of Visual Perceptual Skills" (TVPS) that has not been previously reported in children with ADHD enrolled in such a program.

Methods: Sixteen children, 7–11 years old, with ADHD were involved in occupational therapy and special education geared towards attention training. Six months later methylphenidate 1 mg/kg/day was prescribed. It was not taken by eight children because of family choice. The TVPS was given twice, upon diagnosis, and 8 months post-intervention. The groups were compared by a repeated measures analysis of variance (ANOVA) with medication as a between groups factor and test-retest scores as within factor.

Results: All children demonstrated increases in total scores in the second measurement. Medicated children scored higher but ANOVA showed a nonsignificant F for the two groups, medicated and unmedicated ($F = 0.0031$, $p = 0.9563$), indicating a nondifferential effect of the two levels of treatment. It revealed a significant F for the pre- and post-treatment total TVPS scores ($F = 30.91$, $p < 0.0001$) indicating a significant difference between pre- and post-treatment tests. The interaction between pre-post treatment and level of treatment (medicated–unmedicated) was nonsignificant ($F = 2.20$, $p = 0.1604$).

Conclusion: TVPS scores improved in all children following intervention. Medicated children did better, but differences were nonsignificant.

Keywords: ADHD, stimulants, psycho-educational therapy, TVPS

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most frequent chronic conditions of childhood, occurring in 4%–12% of school age children (AAP 2001); it has a significant impact on child mental health and education. Accurate diagnosis, measurement of impairment, and monitoring of symptoms overtime are important for successful management. The treatment of ADHD includes stimulants and/or psycho-educational interventions. Stimulants are effective in controlling ADHD core symptoms in 70%–80% of the patients; these are considered the safest of all the medications utilized in this condition (Olfson et al 2003). The evidence supporting medication-based interventions is strong; consensus treatment algorithms to guide the multimodal treatment of ADHD, alone and in combination with common co-morbidities, have been discussed (Remschmidt 2005). Methylphenidate, the most frequently used stimulant, gives better motivation and drive than the others making patients work more intensely; the duration of its effect is short, but the breadth of its impact is impressive (Conners 2002). Treatment with stimulants is more effective in the reduction of

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ADHD symptoms than an intensive program of behavioral and cognitive intervention; the combination of stimulants with psychosocial interventions offers few advantages over medication alone (Santosh and Taylor 2000). The Multimodal Treatment Study concluded that careful medication management with good follow-up is more effective than intensive behavioral treatment (The MTA cooperative group 1999); combination of medication and intensive behavioral treatment was also significantly superior to psychosocial treatments alone in reducing ADHD symptoms. Nevertheless, many societies and child health specialists prefer to rely on psycho-educational interventions such as occupational therapy, special education, and psychotherapy, rather than stimulants, despite the cost and the time investment involved (Nianiou et al 2003). The literature provides little support for expanded psycho-educational treatment options and stresses the need for well-designed rigorous studies (AAP 2001). Neuropsychological evaluation of children with ADHD is often requested on diagnosis along with behavioral rating scales for parents and teachers (Biederman et al 2004). However, measuring progress of children involved in treatment is not routinely done. The reason for this could be related to assessment difficulties; lengthy testing sessions are counterproductive because attention problems interfere with the process and create difficulties in the interpretation of incorrect results. Testing for treatment response in individual children with ADHD has not been adequately evaluated (Mollica et al 2004). The clinical effectiveness of stimulant medications is no longer in doubt but the efficacy of psycho-educational interventions and the patterns of changes in ADHD need to be explored. Perceptual and spatial disorders have been much less investigated than other domains. Visual perception is the capacity to interpret or give meaning to what is seen; it includes recognition, insight and interpretation of what is seen, at the higher levels of the central nervous system (Buktenica 1968). Visual perceptual skills have not been studied in children with ADHD. They have been investigated in children with reading problems and have been found to probably contribute to them (Griffin et al 1993) as well as in children with cerebral palsy (Menken et al 1987; Stiers et al 2002).

The objective of this investigation was to examine changes in a TVPS that has not been previously utilized in children with ADHD, before and after intervention with individualized psycho-educational training and stimulants. We hypothesized that all children were going to have significant changes in their TVPS scores in the second time of measurement.

Methods

Patients

Sixteen children, 13 boys and 3 girls, 7–11 years of age (mean age 8 years and 3 months) were enrolled in the study. The patients were included on the basis of fulfilling DSM-IV ADHD diagnostic criteria (APA 1994) and being students of regular schools. They were all considered good candidates for stimulant medication. Comorbidity with other conditions commonly seen in children with ADHD, resource class, or other type of tutoring within the school system were not exclusion criteria. According to our treatment protocol for children with ADHD, all of them were referred for comprehensive psycho-educational testing and intervention prior to the initiation of stimulant treatment. After the testing was completed they became involved in a 5-hour/week remedial program of occupational therapy and special education that was carried out by the same team of occupational therapists, special educators, and clinical psychologists. The psycho-educational training was individually tailored to each child's needs and flexible enough to accommodate for changes. Occupational therapy was geared towards attention training; it was based on therapeutic principles of motor-perceptual training, cognitive-perceptual training, and sensory integration. Special education included psycho-paedagogic sessions based on behavioral techniques; additionally, an educational program in accordance to the grade level of the child was followed. After 6 months of psycho-educational activities methylphenidate was prescribed at a dose of 1 mg/kg/day, divided in 3 daily doses, to be given at 8 am, 12 noon, and 4 pm. Eight children (6 boys and 2 girls, mean age 7 years and 11 months) took the medication as prescribed and 8 (7 boys and 1 girl, mean age 8 years and 6 months) did not, because the families chose not to proceed with medication due to their own fears and beliefs regarding stimulant use. All children regardless of medication status continued the psycho-educational intervention.

Measures

The TVPS (nonmotor) Revised (TVPS-R) was utilized (Gardner 1996). This test consists of seven subtests: 1. *Visual discrimination*, which refers to a subject's ability to match or determine exact characteristics of two forms when one of the forms is among similar forms. 2. *Visual memory*, which refers to a subject's ability to remember for immediate recall (after 4–5 seconds) all of the characteristics of a given form, and being able to find this form from an array of similar forms. 3. *Visual spatial-relationships*, which refers to a subject's ability to determine the correct direction of forms (spatial relations). 4. *Visual form-constancy*, which refers to a subject's ability to see a form, and being able to find it, even though the form is rotated, reversed, or hidden among others. 5. *Visual sequential-memory*, which refers to a subject's ability to remember a number of forms in a series. 6. *Visual figure-ground*, which refers to a subject's ability to perceive a form visually, and to find this form hidden in a conglomerated ground of matter. 7. *Visual closure*, which refers to a subject's ability to determine, from among 4 incomplete forms, the one that would be the same as the completed one.

TVPS-R measures to what extent a subject (4–13 years) can perform in the above subtests. Directions require a minimum amount of language and can be given in any language. In fact it is described as a test nonbiased for culture, gender, and education. From the original raw scores determined for each subtest the following derived scores are obtained: Standard scores for each age level, percentile ranks, and perceptual ages. These derived scores allow comparisons of the subjects' performance to that of normal children of the same age-group. The test was given twice; first, upon diagnosis and prior to any intervention and subsequently, eight months after occupational therapy and special education were initiated. In the medicated group the test was carried out one hour after methylphenidate administration.

Statistical analysis

In our study we had two experimental conditions (medicated and nonmedicated children) and different subjects have been used in each condition. In order to compare the mean total scores, an analysis of variance has been performed. Because we had a pre-treatment and a post-treatment test and one experimental condition with two levels (medicated and nonmedicated) we performed a two-way analysis of variance (mixed model) with one between variable having two levels (a. education plus medication and b. education without medication) and one within variable also having two levels (a. pre-treatment test and b. post-treatment test). The dependent variable was the total TVPS scores which was composed of 7 sub-scores.

Results

In Table 1 the age, sex, ADHD type, co-morbidity, and medication status of the children are listed. The comprehensive psycho-educational testing that preceded the remedial treatment program revealed that in addition to the ADHD, four children had borderline intelligence, six were dyspraxic, and three dysgraphic. Three children did not demonstrate associated co-morbidity.

After all data were collected and the standard scores were obtained, we performed descriptive statistics on each variable. Table 2 indicates the means, standard deviations, and ranges of the total and sub-category scores in both tests, in medicated and nonmedicated patients. As we can see, both medicated and nonmedicated children appear to have an increase in their score means in the second time of measurement with the exception of closure category in the nonmedicated group where a small decrease was noticed (from mean 5.375 ± 3.02 to mean 4.25 ± 3.732).

Subsequently, in order to compare all groups a 2X2 mixed analysis of variance was performed with medication as a between groups factor and test- retest scores as within factor. At first, a t-test was performed for the purpose of detecting any differences between the total TVPS scores of the two groups (medicated and nonmedicated) in the pre-treatment condition. The t-test value was nonsignificant ($t = 0.0031$, $p = 0.741$), indicating that the two groups (medicated and nonmedicated) were equivalent. The analysis of variance (Table 3) resulted in a nonsignificant F for the two groups, medicated and nonmedicated ($F = 0.0031$, $p = 0.9563$), indicating that there was no differential effect of the two levels of treatment. Furthermore, the analysis of variance revealed a significant F for the pre-treatment and the post-treatment total TVPS scores ($F = 30.91$, $p < 0.0001$) indicating that there was a significant difference between the pre-treatment and the post-treatment tests. The interaction between pre-post treatment and level of treatment (medicated – nonmedicated) was nonsignificant ($F = 2.20$, $p = 0.1604$). As we can observe from the mean values on Table 2; both groups (medicated and nonmedicated) started with an equivalent total score on TVPS and, in the post-treatment test, both groups improved considerably, and the medicated children did better. The sample was smaller than required in order to allow for analysis of the subcategory scores.

Discussion

The findings of this study supported our initial hypothesis; all children enrolled in intervention had significant changes in the TVPS total scores in the second time of measurement. This was noted irrespective of medication status with one exception in the score means in closure category in the nonmedicated group. These improvements were not merely the result of normal development because the analysis was done on standard scores for each age level that allowed comparisons of the subjects' performance to that of normal children of the same age-group. The aim of this study was not to examine the effect of the stimulants versus that of the remedial program

Table1 Age, sex, ADHD type, co-morbidity, and medication status of the children

Patient number	Age (months)	Sex	ADHD type	Co-morbidity	Medication status
1	84	F	Combined	Dysgraphia	Methylphenidate
2	103	M	Combined	Borderline Intelligence	Methylphenidate
3	93	M	Combined	Borderline Intelligence	Methylphenidate
4	93	M	Combined	Dyspraxia	Methylphenidate
5	115	M	Combined		Methylphenidate
6	103	M	Combined	Dyspraxia	Methylphenidate
7	87	F	Combined	Dysgraphia	Methylphenidate
8	84	M	Combined		Methylphenidate
9	123	M	Combined		No
10	99	M	Combined	Dyspraxia	No
11	119	M	Combined	Dyspraxia	No
12	88	M	Combined	Dysgraphia	No
13	92	F	Combined	Borderline Intelligence	No
14	120	M	Combined	Dyspraxia	No
15	94	M	Combined	Dyspraxia	No
16	96	M	Combined	Borderline Intelligence	No

Abbreviation: ADHD, attention deficit hyperactivity disorder.

and it was not anticipated that half of the subjects were going to be retested without medication. For this reason a control group was not included and retesting of the medicated children prior to stimulant onset was not planned. It was subsequently ascertained that medicated and nonmedicated children were not significantly different at the outset through a t-test on the pretreatment TVPS scores. Comorbidity with other conditions commonly seen in children with ADHD was present in the majority of the subjects. It was not an exclusion criterion as this is very common, occurring in over 50% of patients; in fact, ADHD overlaps with other disorders at an extremely high rate (Gillberg 2003). Four patients were found to be of

Table 2 Means, standard deviations, and ranges of the total and sub-category TVPS scores in tests in medicated and nonmedicated patients

	Pre-test		Post-test	
	Medicated	Nonmedicated	Medicated	Nonmedicated
	Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)
Total TVPS score	39.25 ± 21.829 (12–72)	43.125 ± 24.098 (7–71)	60.625 ± 25.690 (30–105)	55.5 ± 20.853 (15–87)
Discrimination	5.875 ± 4.086 (1–12)	7 ± 5.01 (1–14)	8.375 ± 5.370 (1–16)	9.5 ± 3.854 (1–13)
Memory	5 ± 3.891 (1–13)	7.625 ± 4.479 (1–13)	9.875 ± 4.190 (2–15)	8 ± 4.175 (2–14)
Spatial Relationships	6.375 ± 6.116 (1–17)	7. 25 ± 5.09 (1–13)	9 ± 7.091 (1–18)	10.25 ± 4.301 (1–14)
Form Constancy	5.5 ± 3.464 (2–12)	6 ± 3.464 (1–11)	8.375 ± 5.041 (1–16)	9.25 ± 2.964 (5–13)
Sequential Memory	5.25 ± 4.097 (1–12)	5.6 ± 4.44 (1–13)	7.625 ± 4.34 (2–14)	6.25 ± 3.196 (1–12)
Figure ground	7.25 ± 3.575 (1–11)	5.375 ± 4.406 (1–14)	10.125 ± 3.482 (5–16)	8 ± 3.817 (1–13)
Closure	4 ± 2.878 (1–9)	5.375 ± 3.02 (1–8)	7.25 ± 3.327 (3–13)	4.25 ± 3.732 (1–12)

Abbreviations: SD, standard deviation; TVPS, Test of Visual Perceptual Skills.

Table 3 Two by two mixed analysis of variance

Source of variation	SS	df	MS	F	Prob > F
Between subjects variable					
Medication status	3.125	1	3.125	0.0031	0.9563
Subjects (within medication status)	14032.375	14	1002.312		
Within subjects variable					
Pre-test / Post-test	2278.125	1	2278.125	30.91	0.0001
Interaction	162	1	162	2.20	0.1604
Residual	1031.875	14	73.705		
Total	17507.5	31	564.758		

borderline intelligence at the initial evaluation. IQ testing may not be reliable in untreated children with ADHD because of inattention and it is often underestimated; moreover, it has been shown that visual perception impairment and intelligence impairment may coexist as two separate and irreducible deficits (Stiers 1999). For these reasons we did not exclude these children from the study.

The importance for a consensus on the processes that are necessary in monitoring children with ADHD after a treatment plan has been established, has been previously stressed (Foy and Earls 2005). The TVPS was chosen as an outcome measure because it is brief and easy to administer, important factors when assessing children with ADHD. It is frequently utilized by occupational therapists to monitor the progress of children involved in training. The test-retest reliability of the total TVPS scores has been demonstrated in learning disabled children (McFall et al 1993; Burtner et al 2002) and in Chinese preschoolers (Chan and Chow 2005). In contrast, the test-retest reliability estimates scores on the subtests were low and should be used with extreme caution. In the present study the TVPS was useful in measuring the progress of children with ADHD following a treatment program.

How can we explain the improvement of visual perceptual skills when applying techniques that enhance attention? Attention has a critical role in information processing. Its adequate functioning is required for the development of cognitive abilities including the complex ones involved in scholastic progress. As a result, children with attention deficits often have difficulties in reading, writing, and arithmetic. Attention comprises different processes and is fundamentally involved in various cognitive functions. According to Posner and Petersen (1990), attention encompasses the following subsystems: orientation to sensory stimuli, filtering and selection of inputs, and maintenance of the thought on a stimulus, mental activity, or goal. Impaired attention hinders information processing at multiple levels and has been used as an explanation for the functional decline that occurs in aging and dementia. Impairments of attention in early dementia may contribute to performance reductions in other cognitive domains, including memory and executive functions (Rizzo 2000). It is possible therefore that improvements in the tested visual perceptual skills were the by-product of the enhanced attentional processing skills that was accomplished through this treatment schedule. We did not however document a significant effect of methylphenidate even though medicated children scored higher in the second measurement (Table 2). Methylphenidate improves vigilance performance, short-term memory performance, and visual problem solving (Swanson et al 1993). There is short-term benefit of stimulants regarding increased concentration and improving on-task behavior, whereas the long-term studies are difficult to evaluate because of methodological problems (Douglas et al 1988). In one study the longer term stimulant-treated group had better executive function performance (Vance et al 2003). Nevertheless, stimulants and other medications are unable to completely ameliorate all the difficulties for all children with ADHD. Therefore, attention needs to be directed toward psycho-educational interventions and their ability to increase the successful functioning of children with ADHD (Hoffman and DuPaul 2000). The deficit in working memory in children with ADHD can be improved by training; this also improved response inhibition and reasoning and resulted in a reduction of the parent-rated inattentive symptoms of ADHD (Klingberg 2005).

Conclusion

Visual perceptual skills improved in children enrolled in individualized psycho-educational intervention, irrespective of stimulants. The effect of the stimulants could have been investigated if the same children had been examined serially, after psycho-educational training, before and after methylphenidate administration. A larger sample of patients and a carefully executed design is important for this purpose.

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