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Summary
The Role of Attention on the Intelligence Test Scores of Patients with Attention Deficit Hyperactivity Disorder

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Attention deficit hyperactivity disorder (ADHD) is a syndrome that appears during childhood and is defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-R, American Psychiatric Association, 2005) and the International Classification of Diseases (ICD-10; World Health Organization, 1992). Subtypes of ADHD are differentiated by symptoms of attention deficit (AD) and/or hyperactivity/impulsivity (HI).

The Wechsler Intelligence Scale for Children-Revised (WISC-R) is a frequently used psychometric tool in ADHD because it not only assesses the level of intelligence but is also used as an auxiliary tool in ADHD diagnosis (Bhatia, Nigam, Bohra, & Malik, 1991; Ehlers et al., 1997; Erdoğan Bakar, Soysal, Kiriş, Şahin, & Karakaş, 2005; Evinç & Gençöz, 2007; Greene et al., 1996). Intelligence scores show a normal distribution in ADHD patients; however, ADHD cases score 7-15 points lower than do age-matched controls (Faraone et al., 1993; Fischer, Barkley, Fletcher, & Smallish, 1990; Frazier, Demaree, & Youngstom, 2004; McGee, Williams, Moffitt, & Anderson, 1989; Prior, Leonard, & Wood, 1983; Tarver-Behring, Barkley, & Karlsson, 1985; Werry, Elkind, & Reeves, 1987).

Investigations of the origin of these lower intelligence scores have produced conflicting results. The literature presently considers all possible alternatives, including a lower Performance IQ (Bhatia, Nigam, Bohra, & Malik, 1991; Ehlers et al., 1997; Gabel, Oster, & Butnik, 1986; Gilberg, Ramussen, Carlstrom, Svenson, & Waldenström, 1982; Mahone et al., 2003; Öktem & Sonuvar, 1993; Whalen, 1989), a lower Verbal IQ (Greene et al., 1996; Kaufman, 1979; Klorman, Coons Borgstedt et al., 1987; Kuperman et al., 1996; Seidman, Biederman, Faraone, Weber, & Menin, 1997a; Seidman, Biederman, Faraone, Weber, & Ouellette, 1997b; Wachs & Sheehan, 1988) and low values on both the Performance and Verbal IQ subtests (Frazier, Demaree, & Youngstrom, 2004; Kiriş & Karakaş, 2004). Analyses of the subtest scores have also yielded various combinations of subtests that exhibit significant differences between the ADHD and healthy control groups (Biederman et al., 2007; Ehlers et al., 1997; Erdoğan Bakar, Soysal, Kiriş, Şahin, & Karakaş, 2005; Evinç & Gençöz, 2007; Faraone et al., 1993; Gabel, Oster, & Butnik, 1986; Kaufman, 1979; Loge, Staton, & Beatty, 1990; Seidman Biederman, Faraone, Weber, & Menin, 1997a). However, these studies demonstrate a tendency toward lower scores in the ADHD group on the Arithmetic, Digit Span and Coding subtests. According to one popular study (Kaufman et al., 1997), these subtests measure attention.

However, attention is not a unitary phenomenon. Active attention has a limit of 7±2 units (Dye, 1982; Miller, 1956; Jurdeni, Laiple, & Jones, 1993; Roth, Conboy, Reeder, & Boll, 1990). Within the bounds of this developmentally affected limit (Karakaş, Yalın, Irak, & Erzengin, 2002), attention controls how resources are to be allocated between stimuli and between responses; this control can be excitatory or inhibitory (Anderson, Reder, & Lebiere, 1996; Hasher & Zacks, 1988). Attention operates not only at the sensory and perceptual stages of information processing (Dempster, 1993; Nigg, 2000) but also at the central executive stage (Baddeley, 1996; Parshler, 1999; Sturm & Zimmermann, 2000). According to one large-scale study (Schweizer, Moosbrugger, & Goldhammer, 2005), tests of executive attention and control explain 32% of the variance in fluid intelligence.

The present study tests the hypothesis that the lower scores of the ADHD group in subtests of the WISC-R do not reflect a lower level of intelligence but originate from a basic inability to attend to information.

Method

The study was conducted on a sample of 356 boys (age range: 72-149 months). There were 143 boys in the healthy control group and 215 boys in the ADHD group.

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Of this ADHD group, there were 72 boys in the Predominantly Attention Deficit subtype, 41 boys in the Predominantly Hyperactivity/Impulsivity subtype and 102 boys in the Combined subtype. The diagnoses were made according to DSM-IV, and the symptoms of comorbidity were checked using the K-SADS (Schedule for Affective Disorders and Schizophrenia for School Age Children-Present and Lifetime Versions).

Intelligence was measured using the Wechsler Intelligence Scale for Children-Revised: WISC-R (Wechsler, 1949; 1974; Turkish standardization by Savaşır & Şahin, 1995). All of the subtests were administered; however, the Verbal IQ was calculated without the Vocabulary score, and the Performance IQ was calculated without the Labyrinth score.

The Stroop Test (STP) (Stroop 1935, Turkish standardization by Karakaş et al., 1999a; Karakaş, Irak, Kurt, & Erzengin, 1999b; Kılıç, Koçkar, Irak, Şener, & Karakaş, 2002c) was used to measure selective attention (subtests STP2, STP4 and STP5), focused attention (subtests STP1 and STP3) and resistance to interference (subtest STP5). The Verbal and Nonverbal Cancellation Tests (CT) (Weintraub and Mesulam, 1985; Turkish standardization by Cantez et al., 1996; Kılıç, Irak, Koçkar, Şener, & Karakaş, 2002a; Kurt & Karakaş, 2000) were used to measure sustained attention. The Visual Aural Digit Span Test-B Form was used to measure the attentional capacity (Karakaş & Yalın, 1993; 1995; 2009).

Data were obtained at three institutions (the Psychology Department and Child Neurology Department of Hacettepe University and the Pediatrics Department of Gazi University). The informed consent of the parents and the approval of the participants/patients were obtained. Psychiatric and neurological examinations were carried out, and the cases with psychiatric or neurological comorbidity, those with clinical levels of depression and anxiety and those under medication were not included in the sample. The tests were administered by three trained testers in chambers that were suitable for psychometric testing.

Results

According to Multivariate Analysis of Covariance (MANCOVA), 9 out of 12 of the WISC-R scores of the ADHD group were significantly lower than those of the control group. When selective/focused attention and interference control (STP), sustained attention (CT) and attentional capacity (VADS-R) were statistically controlled in MANCOVA, the significant differences on all of the subtests of Performance IQ and on four of the subtests of Verbal IQ ceased to exist. The two scores that continued to exhibit significant differences were from the General Information and Vocabulary subtests. Principal Component Analysis (PCA) revealed that each of the three neuropsychological test scores loaded on three different factors. With the exception of the digit span score, the WISC-R scores loaded on a fourth factor. The digit span score took place under the fourth factor, under which the VADS-R score also took place. According to the Logistic Regression Analysis, the total correctness of estimation for classifying boys between the ADHD and the control groups was higher when the predictor variables were the scores on the neuropsychological tests of attention (83.1%). When the predictor variables were the 12 subtest scores of the WISC-R, the correctness of estimation fell to 73.7%. When the predictor variables were the WISC-R scores that allegedly represent attention, the correctness of estimation was at 66.4%.

Discussion

The present study controlled for the contaminating effect of the subject variables (e.g., sex, age, comorbidity and medication) by the research design and statistical means. Measurements were obtained from valid and reliable neuropsychological tests of attention (Doğutepe Dinçer & Karakaş, 2008; Karakaş, 2006a; Karakaş & Doğutepe Dinçer, 2011a; 2011b). Under these conditions, the findings of the study indicated that significantly lower intelligence scores are secondary to disorders of attention. An inability to select, focus and sustain attention was concomitant with lower scores on intelligence, as would also be expected for all cognitive processes.

Lower WISC-R scores were observed in the ADHD group; these results were selective to neither the verbal subtests nor the performance subtests. In accordance with the literature, the differences between the Similarities and Picture Completion subtest scores were not significant (Ehlers et al., 1997; Erdoğan Bakar, Soysal, Kiriş, Şahin, & Karakaş, 2005; Evinç & Gençöz, 2007; Faraone et al., 1993; Gabel, Oster, & Butnik, 1986; Kaufman, 1979; Loge, Staton, & Beatty, 1990; Palmer, 1983; Rucklidge & Tannock, 2001; Seidman, Biederman, Faraone, Weber, & Menin, 1997a; Seidman, Biederman, Faraone, Weber, & Ouellette, 1997b). These findings can be explained through a cognitive process that influences and modulates all other cognitive processes. In the present study, this process was hypothesized to be attention (Barkley, DuPaul, & McMurray, 1990). In fact, previous studies have also proposed a similar explanation (Ehlers et al., 1997; Evinç & Gençöz, 2007; Erdoğan Bakar Soysal, Kiriş, Şahin, & Karakaş, 2005; Faraone et al., 1993; Gabel, Oster, & Butnik, 1986; Greene et al., 1996; Kaufman, 1979; Klorman, Coons, & Borgsted, 1987; Kuperman et al., 1996; Loge, Staton, & Beatty, 1990; Palmer, 1983; Rucklidge & Tannock, 2001; Seidman, Biederman, Faraone, We-

ber, & Menin, 1997a; Seidman, Biederman, Faraone, Weber, & Ouellette 1997b; Wachs & Sheehan, 1988). The shortcoming in this group of studies was the lack of a consistent pattern among the affected tests (Bhatia, Nigam, Bohra, & Malik, 1991; Ehlers et al., 1997; Gabel, Oster, & Butnik, 1986; Gilberg, Ramussen, Carlstrom, Svenson, & Waldenström, 1982; Mahone et al., 2003; Öktem & Sonuvar, 1993; Whalen, 1989). A similar diversity has been observed with respect to theories of ADHD that have emphasized attention (Barkley, 1997; Barkley, 1998; Satterfield & Cantwell, 1974; Scheres et al., 2004; Stuss & Benson, 1986; Zental & Zental, 1983).

The present study indicated that the statistical control of critical tests of attention diminished the statistically significant differences for only the General Information and the Vocabulary scores. These two subtests belong to a category that is closely related to curricular achievement: Acquired Knowledge (Bannatyne, 1968; 1971). The types of attention that are controlled in this study did not affect the subtests of Acquired Knowledge; evidently, academic achievement requires assets other than the ones that were investigated in the present study (Barry, Lyman, & Klinger, 2002; Diamantopoulou, Rydell, Thorell, & Bohlin, 2007; Antshel et al., 2007). This conclusion was supported in the present study by the findings of the principal component analysis. The subtests scores of Acquired Knowledge loaded on one factor; the rest of the scores on types of attention were distributed among the remaining factors.

The sample of the present study consisted of only males; this is one limitation of the study. Due to the extensive testing time, an extra battery for Specific Learning Disability (SLD) could not be added to the measurement kit; the disorder was therefore clinically evaluated. Future studies should study both sexes and extend the spectrum of the psychometric tools. The clinical symptoms of attention deficit and hyperactivity/impulsivity are generally treated using methylphenidate. If lower WISC-R scores are obtained because of deficits in attention, methylphenidate treatment should increase the WISC-R scores. The few studies on this topic have yielded conflicting results. Another line of future research can test the hypothesis of the present study using a pre-test and post-test comparison of methylphenidate treatment under controlled research conditions.