Differences in academic and executive function domains among children with ADHD Predominantly Inattentive and Combined Types

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Abstract

Differences between the subtypes of Attention Deficit Hyperactivity Disorder (ADHD) continue to have a place in the clinical and research literature. The purpose of this study was to examine differences specific to academic and executive function deficits in a sample of 40 children, aged 9–15 years. Although there was a tendency for the Predominantly Inattentive (PI) group to evidence lower performance on calculation and written expression tasks, these differences dissipated when IQ was included as a covariate. For executive function domains of set shifting, interference, inhibition, and planning, differences emerged for interference, but only when girls were excluded from the analysis and no control for IQ was made. For parent ratings of executive function, expected differences were found on the Inhibit scale with the Combined Type (CT) group evidencing greater problems in this area; this difference remained even when girls were excluded and IQ was controlled. Implications for research and practice are presented.

Keywords: Attention Deficit Hyperactivity Disorder (ADHD); Predominantly Inattentive (PI); Combined Type (CT)

1. ADHD subtypes

Historically, there has been controversy regarding the existence of subtypes of Attention Deficit Hyperactivity Disorder (ADHD). Initially conceptualized as minimal brain dysfunction, there was no distinction between types of ADHD. Later, the emphasis shifted to the hyperactivity component with hyperkinetic syndrome in the Diagnostic and Statistical Manual of Mental Disorders (2nd edition: DSM-II, American Psychiatric Association [APA], 1968). With the next revision, in the DSM-III (APA, 1980), the disorder was compartmentalized into Attention Deficit Disorder with Hyperactivity (ADDH) and Attention Deficit Disorder Without Hyperactivity (ADDWo). Research using these subtypes suggested that the Hyperactive and Inattentive groups manifest different cognitive deficits as well as differing behavioral profiles (e.g., Cantwell & Baker, 1992). With the next revision of the DSM (APA, 1987), the subtypes were eliminated and criteria described a very heterogeneous group of individuals as having ADHD. With the DSM-IV (APA, 1994, 2000), subtype differentiation is again advocated with three subtypes: Predominantly Inattentive (PI), Predominantly Hyperactive–Impulsive (HI), and Combined Type (CT), as well as ADHD Not Otherwise Specified (NOS).

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Multiple studies examined the differences in subtypes as specified in the DSM-III as ADD with and without hyperactivity (e.g., Barkley, 1990, 1998; Goodyear & Hynd, 1992; Lahey, Carlson, & Frick, 1997; Lahey, Schaughency, Hynd, Carlson, & Nieves, 1987; Lahey, Schaughency, Strauss, & Frame, 1984; Marshall, Hynd, Handwerker, & Hall, 1997). Using the criteria from the DSM-III, children diagnosed with ADD without hyperactivity were more likely to experience cognitive processing problems and learning disabilities, as well as to have a higher likelihood of internalizing disorders. In academic areas, for example, Marshall et al. (1997), as well as Marshall, Schafer, O’Donnell, Elliott, and Handwerk (1999), found that math achievement was significantly lower for children diagnosed with ADD without hyperactivity. These findings replicated findings of others suggesting impaired math achievement for ADD without hyperactivity (e.g., Carlson, Lahey, & Neepe, 1986; Hynd et al., 1991). Related to math achievement, Ackerman, Anhalt, Holcomb, and Dykman (1986) found that children with ADD without hyperactivity had decreased math fluency.

Taken together with their finding that these children’s written production was also decreased relative to children with ADD with hyperactivity, their findings supported the notion that children with ADD without hyperactivity have sluggish cognitive tempo (e.g., Lahay, Schaughency, Frame, & Strauss, 1985; Lahay et al., 1987). Findings of decreased rapid naming ability (e.g., Hynd et al., 1991), as well as decreased perceptual motor speed and lethargy (e.g., Barkley, DuPaul, & McMurray, 1992), further supported cognitive tempo as different between these two subtypes as defined in the DSM-III. Additional neuropsychological studies that examined difference for DSM-III subtypes are reviewed elsewhere (e.g., Goodyear & Hynd, 1992).

Since the re-specification of criteria for ADHD subtypes, a number of studies have continued to support the notion that academic problems are linked to attention problems (e.g., Rabiner, Murray, Schmid, & Malone, 2004), and, therefore, likely to present in both PI and CT subtypes. Further, it has been suggested that inattention is related to poor reading comprehension among children with PI type (Aaron, Joshi, & Phipps, 2004). Others continue to find a higher frequency of learning disabilities, as well as speech and language concerns, to be associated with PI (Wiess, Worling, & Wasdell, 2003). As with earlier studies, electroencephalographic study of samples of children with ADHD using DSM-IV criteria supports the theory that different neuroanatomical systems are involved based on the subtype of ADHD (Clarke, Barry, McCarthy, & Selikowitz, 2001). Similar study with event-related potential also provides support for differentiation of subtypes of ADHD at least in children ages 8–12 years (Johnstone, Barry, & Diomoska, 2003; Smith, Johnstone, & Barry, 2003).

Previously, there had been some discussion of the nature of the attention deficits associated with the ADDWo subtype. Specifically, these theories postulated the involvement of the posterior (right inferior parietal lobe) with the inattention associated with PI and involvement of more anterior (frontal) structures with CT (e.g., Posner & Raichle, 1994; Schaughency & Hynd, 1989; Stormark, Hugdahl, & Posner, 1999). Recent theoretical conceptualizations (e.g., Barkley, 1997a; Quay, 1997) focus on the CT subtype. In particular, Barkley (1997a, 1997b) argued that the deficits in CT are qualitatively different from those in PI, but he did not expand on any theoretical conceptualization of PI. At the same time, central to Barkley’s theory is the hypothesis that disinhibition and related executive function deficits are defining characteristics of CT rather than attentional deficits.

Barkley (1997a, 1997b) differentiated CT from PI from the perspective of the underlying processes. Specifically, instead of attention problems as a focus, the ability to use hindsight and forethought play key roles in his explanation of the disinhibition associated with CT. With disinhibition providing the key to understanding, and the relative absence of disinhibition in PI, Barkley’s (1997a, 1997b) theory or model asserts different underlying mechanisms as well as differential manifestation. Conceptually, it is expected that individuals with CT would demonstrate deficits in inhibitory control and planning. In contrast, deficits in set shifting, vigilance, and interference control may be more associated with PI (Barkley, 1997a; Quay, 1997) focus on the CT subtype. In particular, Barkley (1997a, 1997b) argued that the deficits in CT are qualitatively different from those in PI, but he did not expand on any theoretical conceptualization of PI. At the same time, central to Barkley’s theory is the hypothesis that disinhibition and related executive function deficits are defining characteristics of CT rather than attentional deficits.

Since the advent of the DSM-IV and theoretical perspectives on ADHD, several studies have examined the extent to which CT and PI types differ on various cognitive and executive measures (e.g., Faraone, Biederman, Weber, & Russell, 1998; Houghton et al., 1999; Klorman et al., 1999; Nigg, 2001; Nigg et al., 2002; Pennington & Ozonoff, 1996). Research clearly supports the notion of differences in neuropsychological profiles of children with the differing subtypes of ADHD (e.g., Barkley, 1997a; Bauermeister, Bird, Canino, & Rubio-Stipec, 1995; DuPaul et al., 1997; Goodyear & Hynd, 1992; Schaughency & Hynd, 1989). Nigg, Goldsmith, and Sachek (2004) described the PI subtype as characterized by inattention-disorganization, possibly reflecting problems with effortful control. Alternatively, Collings...
argued that there was no evidence of sustained attention or vigilance problems with PI, but found that the group of participants with CT evidenced rapid deterioration in their ability to maintain attention.

Consistent with previous findings for ADDWo, Carlson and Mann (2002) suggested that sluggish cognitive tempo is characteristic of PI. They reported for their sample that the PI group was higher on underactivity and apathy than the CT or normal comparison groups. Bauermeister et al. (2005) found that PI was associated with more symptoms suggestive of sluggish cognitive tempo; McBurnett, Pfiffner, and Frick (2001) argued for consideration of sluggish tempo in the diagnosis of PI. In contrast, Todd, Rasmussen, Wood, Levy, and Hay (2004) found that although differences in profiles emerged by gender when including sluggish cognitive tempo items, the addition of the items had minimal impact on the latent class analysis. In the Hartman, Willcutt, Rhee, and Pennington (2004) study that investigated the combination of the 18 items from the DSM-IV and 5 sluggish cognitive tempo items, they found that instead of aligning with either subtype, the sluggish cognitive tempo items loaded on a separate factor. At the same time, however, they found that the sluggish tempo items were endorsed more frequently for the PI group than for the CT group. In another study examining subtype differences, Chhabildas, Pennington, and Willcutt (2001) compared children with ADHD subtypes with controls and with each other on the Trail Making Test total time. Both ADHD groups differed significantly from the control group; the CT group performed significantly better than the PI group, but significantly worse than the control group. Chhabildas et al. (2001) found that Inattentive symptoms predicted total time on the Trail Making Test ($R^2 = 35.6$) equally as well as the Hyperactive/Impulsive symptoms ($R^2 = 37.2$). Thus, some notion of sluggish processing continues to be associated with the PI subtype, but research is equivocal.

Lockwood, Marcotte, and Stern (2001) compared 20 boys and 20 girls with ADHD-PI and ADHD-CT ($N = 80$) on various neuropsychological measures grouped according to components of attention based on Cohen’s (1993) model of attention. Results indicated that subtypes differed significantly on the Sensory Selection component (e.g., Digits Forward, TMT-A Time, Story Memory, figure copying). In addition, results indicated an interaction effect between subtype and gender for the Response Selection component (e.g., TMT-B Errors, Cancellation Task Commission Errors, fluency, fluency rule violations). Both subtypes evidenced similar deficits on Capacity/Focus (e.g., Digits Backward, figure recall, TMT-B Time, syntactic comprehension) as well as on the Sustained Attention component (e.g., Cancellation—Time, fluency decrement). Using discriminant analysis, results indicated that of the variables included, five variables discriminated participants with ADHD-PI from those with ADHD-CT with 80.0% accuracy. These five variables were verbal fluency rule violations, Story Memory, Syntactic Comprehension, TMT-B Errors, and Shape Cancellation Time/Correct Hits. Faraone et al. (1998), however, did not find marked differences in cognitive or psychosocial functioning across neuropsychological measures.

In still another study, Nigg et al. (2002) examined five behavioral components of executive function. The first four of these were based on Pennington’s (1997) model of executive functioning, specifically inhibition, planning, interference, and set shifting. The final component was that of response speed as reflective of effort or arousal. Nigg et al. (2002) compared children, ages 7–12 with PI ($N = 18$) or CT ($N = 46$) subtypes to a control group ($N = 41$) on various measures of neuropsychological functioning. Both ADHD groups demonstrated slowed responding. Although slower in responding, neither ADHD group demonstrated impairment on the Stroop. Only the CT group demonstrated deficits in planning; only boys with CT demonstrated problems with inhibition on a stop signal task. The purpose of this study was to examine differences in academic and executive function for a sample of children diagnosed with either PI or CT.

2. Method

2.1. Participants

Children included in this study were drawn from a larger sample of children (aged 9–15 years) who were consecutive referrals to a university-based research study. Participants for the larger study were recruited through the use of announcements distributed in the local community to physicians, local schools, a community-based counseling center, on local bulletin boards, and in the local newspaper. The announcement indicated that the research study focused on memory, attention, and planning/problem-solving, but did not directly mention ADHD. Participation was voluntary with consent obtained from the parent and assent obtained from each participant. For inclusion in the study, children had to obtain an IQ greater than or equal to 80; children had to speak and read English. Additional criteria for exclusion included a previous diagnosis of schizophrenia or history of severe head injury.
Table 1
Demographic information for the sample

<table>
<thead>
<tr>
<th></th>
<th>ADHD: Predominantly Inattentive (N = 13)</th>
<th>ADHD: Combined Type (N = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent males</td>
<td>100</td>
<td>77.78</td>
</tr>
<tr>
<td>Percent White non-Hispanic</td>
<td>76.92</td>
<td>85.18</td>
</tr>
<tr>
<td>Percent African American</td>
<td>15.38</td>
<td>7.41</td>
</tr>
<tr>
<td>Percent Hispanic</td>
<td>7.69</td>
<td>7.41</td>
</tr>
<tr>
<td>Percent right handed</td>
<td>76.92</td>
<td>92.59</td>
</tr>
<tr>
<td>Percent previously retained</td>
<td>7.69</td>
<td>33.33</td>
</tr>
<tr>
<td>Percent taking medication</td>
<td>30.77</td>
<td>77.77</td>
</tr>
<tr>
<td>Percent receiving special education services</td>
<td>7.69</td>
<td>11.11</td>
</tr>
<tr>
<td>Mean age (S.D.)</td>
<td>12.43 (1.87)</td>
<td>11.53 (2.10)</td>
</tr>
<tr>
<td>Mean parent educational level (S.D.)</td>
<td>14.92 (2.10)</td>
<td>14.89 (2.33)</td>
</tr>
<tr>
<td>Mean Full Scale IQ (S.D.)</td>
<td>96.00 (8.80)</td>
<td>102.44 (10.13)</td>
</tr>
</tbody>
</table>

Note. ADHD: Attention Deficit Hyperactivity Disorder.

For this study, only those children (N = 40) who met criteria for ADHD-CT or PI were included; one participant was diagnosed with ADHD Not Otherwise Specified and was not included. The participants in this study had a mean age 11.98 (S.D. = 2.07); ages ranged from 9.0 to 15.58 years. Of these, 33 (82.5%) were white non-Hispanic, 4 (10%) were African American, and 3 (7.5%) were Hispanic English-speakers; ethnicity was based on parent report. For the total sample, 34 (85.0%) were male and 6 (15.0%) were female. Information on parent educational level indicates a range from 10th grade to medical/legal degree (>16 years); in a majority of cases, at least one parent had completed some college (mean = 14.62 years of education; S.D. = 2.34). The mean cognitive ability of the sample was within the average range (Mean Full Scale IQ = 97.71; S.D. = 12.76). Based on diagnostic considerations, 13 (32.5%) met criteria for ADHD-PI; 27 (67.5%) met criteria for ADHD-CT. Groups did not differ on age, parent educational level, or Full Scale IQ; only the CT group included girls. Demographic information by subtype is provided in Table 1.

2.2. Instruments

In academic areas, given the interest in cognitive tempo, fluency as well as skill attainment in reading, math, and written expression was considered. Although using different executive function measures, performance across tasks was aggregated by domains similar to those examined by Nigg et al. (2002). Given concerns about the level of agreement between observed behaviors and performance on laboratory measures of executive function (Grodzinsky & Barkley, 1999; Weyandt & Willis, 1994), differences in parent reported behaviors believed to reflect executive function were also of interest.

2.2.1. Wechsler Intelligence Scale for Children—third edition (WISC-III; Wechsler, 1991)

The WISC-III is the most frequently used measure of cognitive ability for child populations. All subtests required for computation of the factor scores were administered. The Full Scale IQ was of interest for descriptive purposes, as well as considering it as a potential confound.

2.2.2. Woodcock Johnson Tests of Achievement—third edition (WJ-III; Woodcock, McGrew, & Mather, 2001)

The WJ-III is one of the most frequently used measures of achievement in psychological practice. The standard battery of achievement tests specific to reading, math, and written expression was administered to all participants. With interest in processing speed and cognitive tempo, the subtests related to academic fluency were of interest.

2.2.3. Peabody Picture Vocabulary Test—III (PPVT-III; Dunn & Dunn, 1997)

The PPVT-III is a frequently used measure of receptive vocabulary skills for standard English. It has good validity and reliability with national norms.
2.2.4. Expressive Vocabulary Test (EVT; Williams, 1997)

The EVT is a measure of the individual’s expressive (naming) vocabulary. In conjunction with the PPVT-III, the EVT provides an estimate of basic language abilities. Split-half reliabilities, alpha, and test–retest reliabilities are well within acceptable ranges.

2.2.5. Processing speed

The processing speed index (PSI) score from the WISC-III, comprised of the Coding and Symbol Search subscales, was used as a measure of response speed. The higher score is indicative of faster, more accurate performance. These two subtests frequently are used as measures of processing speed (e.g., Calhoun & Mayes, 2005; Feldman, Kelly, & Diehl, 2004).


Consistent with the Nigg et al. (2002) study, a tower task was used to assess planning ability. For this study, the TOLDX was used; the total move score and total number solved in minimum number of moves, in standard scores, were averaged to operationalize planning ability. High scores on the TOL are indicative of good performance. All items were administered.

2.2.7. Set shifting: Trail Making Test (TMT; Reitan & Wolfson, 1985) and Wisconsin Card Sorting Test (WCST; Heaton, 1981; Heaton, Chelune, Talley, Kay, & Curtis, 1993)

As with Nigg et al. (2002), the TMT was used as one measure of set shifting. Participants were administered both the TMT-A and TMT-B. Time on TMT-A is generally considered as an attentional baseline while time on TMT-B was of interest as a measure of set shifting. Instead of using time on Trails B, the ratio of Trails B to Trails A was used in order to control for possible differences in response speed. The higher the ratio, the more difficulty in set shifting relative to baseline attention that is evident. The Perseveration Errors and Categories Obtained scores on the Wisconsin Card Sorting Test (Heaton et al., 1993) were used as well. Manual card administration of the WCST with 6 categories or 128 card limit was used in this study. Scoring was completed using the scoring program (Heaton, 1999) to ensure consistency. For these two scores, a higher score usually indicates better performance. In order to combine with the TMT ratio score, the average of the standard scores for Perseveration Errors and Categories Obtained was calculated and transformed to a z-score with the direction reversed. The z-score and ratio were then summed with higher scores suggestive of greater deficits.

2.2.8. Interference: Stroop Color and Word Test (Golden, 1978; Stroop, 1935)

Consistent with Nigg et al. (2002), the Stroop interference task was used as a measure of interference control. The Color–Word score often is interpreted as a measure of the individual’s ability to inhibit a prepotent response; Schmitz et al. (2002) found significant differences on the Stroop. Some research, however, suggests that how the interference score is determined can affect the findings and that the Stroop may not be a good measure of interference problems associated with ADHD (van Mourik, Oosterlaan, & Sergeant, 2005). With these concerns in mind, the actual interference score (Color–Word T-score) as well as the derived interference score (T-score) based on the normative data in Golden (2002) were averaged. Higher scores are indicative of better performance.

2.2.9. Inhibition: Conners’ Continuous Performance Test-II (CCPT-II; Conners, 1995)

Motor inhibition in this study was operationalized as commission errors and variability on the CCPT-II. These scores (T-scores) were averaged. For the CCPT-II high scores would indicate impaired performance. The standard parameters were used; the examiner remained in the room during the task administration.

The Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) is a questionnaire completed by parents or teachers to reflect the frequency with which a child aged 5–18 years exhibits specific behaviors. The BRIEF yields eight specific scales and two global scales. With conceptualizations of PI including components of disorganization, the subscales rather than the global scales were of interest. Across scales, higher scores are indicative of more problems in that area.
Table 2
Mean scores (S.D.) for achievement domains by subtype

<table>
<thead>
<tr>
<th></th>
<th>ADHD: Predominantly Inattentive (N=13)</th>
<th>ADHD: Combined Type (N=27)</th>
<th>F(1, 38)</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passage comprehension</td>
<td>95.23 (12.54)</td>
<td>98.88 (9.63)</td>
<td>1.02</td>
<td>.03</td>
</tr>
<tr>
<td>Letter-word recognition</td>
<td>98.38 (9.99)</td>
<td>98.96 (10.24)</td>
<td>0.03</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Reading fluency</td>
<td>93.77 (10.55)</td>
<td>98.31 (13.04)</td>
<td>1.18</td>
<td>.03</td>
</tr>
<tr>
<td>Calculation</td>
<td>95.15 (12.27)</td>
<td>104.00 (10.34)</td>
<td>5.60</td>
<td>.13*</td>
</tr>
<tr>
<td>Applied problems</td>
<td>101.46 (8.19)</td>
<td>104.88 (9.12)</td>
<td>1.30</td>
<td>.03</td>
</tr>
<tr>
<td>Math fluency</td>
<td>84.77 (14.45)</td>
<td>92.42 (12.52)</td>
<td>2.92</td>
<td>.07</td>
</tr>
<tr>
<td>Writing samples</td>
<td>87.54 (16.93)</td>
<td>97.31 (12.83)</td>
<td>4.05</td>
<td>.10*</td>
</tr>
<tr>
<td>Dictation</td>
<td>93.62 (10.44)</td>
<td>98.00 (16.06)</td>
<td>.80</td>
<td>.02</td>
</tr>
<tr>
<td>Writing fluency</td>
<td>90.15 (14.87)</td>
<td>93.85 (14.77)</td>
<td>.54</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. ADHD: Attention Deficit Hyperactivity Disorder.
* $p < .05.$

2.3. Procedures

All individuals participated in a comprehensive assessment including assessment of cognition, achievement, language, memory, executive function, attention, and behavioral/emotional status in a clinic setting. Advanced doctoral students supervised by a licensed psychologist, or a licensed psychologist, administered all measures consistent with standardization. Measures were administered in a random order. Test sessions varied in length based on the individual being assessed. Diagnoses were made independently by two raters based on DSM-IV criteria and the results of parent and teacher behavior rating scales, as well as the Diagnostic Interview for Children and Adolescents (DICA-IV; Reich, Welner, & Herjanic, 1997) with the parent. Raters were blind to the results of the executive function measures. Cohen’s kappa for diagnosis of ADHD by subtype was found to be .86 with an observed proportion of agreement of .90. The focus of this study is on the academic and executive function and only those measures/results are discussed.

3. Results

3.1. Achievement

As an initial indication of subtype differences, the frequencies of co-occurring learning disabilities (based on ability–achievement discrepancy model as used in Texas) were determined. For the PI group, 3 of the 19 students (15.79%) also met criteria for learning disability services (1 for Reading and Written Expression, 1 for Written Expression, and 1 for Reading). For the CT group, five of the students (12.5%) met criteria for learning disability services (one for Reading and Written Expression, one for Reading, and three for Written Expression). All students with identified co-occurring learning disabilities were boys.

To investigate the extent to which subtypes differed in areas of achievement, multivariate analysis of variance (MANOVA) was conducted. Results of the MANOVA were non-significant [Wilks’ Lambda = .80; $p = .61$; $\eta^2 = .20$]. Means, standard deviations, and univariate results are provided in Table 2. Examination of the univariate results indicates that only on calculation and writing samples is there a tendency for subtype differences to emerge such that the PI group obtained lower scores on both subtests as compared to the CT group. When MANOVA was re-run with Full Scale as a covariate, however, these differences dissipated and all partial $\eta^2$ values were below .07.

There are some indications of gender effects on presentation of ADHD symptoms (Biederman et al., 2002; Gaub & Carlson, 1997). Due to the low number of girls in the sample, gender differences could not be explored. To investigate the potential that girls in the CT group were somehow modifying the effects, however, the same analyses were re-run with the girls excluded. Results were still non-significant [Wilks’ Lambda = .77; $p = .67$; $\eta^2 = .23$]. When only boys were considered, differences again tended to be present for calculation and writing samples ($\eta^2$ of .16 and .13, respectively), but, again, decreased once Full Scale IQ was taken into account.

3.2. Language screening

To investigate the extent to which subtypes differed in receptive and expressive language, multivariate analysis of variance (MANOVA) was conducted. Results of the MANOVA were non-significant (Wilks’ Lambda = .95;
Table 3
Mean scores (S.D.) for language domain by subtype

<table>
<thead>
<tr>
<th></th>
<th>ADHD: Predominantly Inattentive (N = 13)</th>
<th>ADHD: Combined Type (N = 27)</th>
<th>F(1, 38)</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peabody Picture Vocabulary Test—III</td>
<td>105.00 (9.51)</td>
<td>109.63 (11.28)</td>
<td>1.63</td>
<td>.21</td>
</tr>
<tr>
<td>Expressive Vocabulary Test</td>
<td>92.08 (13.71)</td>
<td>97.44 (12.14)</td>
<td>1.58</td>
<td>.22</td>
</tr>
</tbody>
</table>

Note. ADHD: Attention Deficit Hyperactivity Disorder.

\( p = .35 \). Means, standard deviations, and univariate results are provided in Table 3. To determine any potential confound of intelligence, MANCOVA was conducted with Full Scale IQ as a covariate. Results were non-significant (Wilks’ Lambda = .99; \( p = .80 \)). To investigate the potential that the non-significant results were due to girls being included, the same analyses were re-run (MANCOVA) with the girls excluded. Results were still non-significant (Wilks’ Lambda = .98; \( p = .69 \)).

3.3. Executive function domains

To investigate the extent to which subtypes differed in executive function domains of set shifting, interference, inhibition, planning, and processing speed, multivariate analysis of variance (MANOVA) was conducted. Results of the MANOVA were non-significant (Wilks’ Lambda = .87; \( p = .31 \)). Means, standard deviations, and univariate results are provided in Table 4. Given the relation between intelligence and executive function (Ardila, Pineda, & Rosselli, 2000; Weyandt, Mitzlaff, & Thomas, 2002), additional analyses were run, controlling for Full Scale IQ. Results were non-significant (Wilks’ Lambda = .90; \( p = .47 \)). To investigate the potential that girls in the CT group were somehow modifying the effects, the same analyses were re-run with the girls excluded. Results were still non-significant (Wilks’ Lambda = .71; \( p = .06 \); \( \eta^2 = .29 \)); however, when only boys were considered, significant differences \( (p = .03) \) emerged for the interference domain, such that the PI group obtained a lower mean score (less optimal performance) as compared to the CT group. With only boys, and covarying for Full Scale IQ, however, results on the interference domain were no longer significant \( (p = .09; \eta^2 = .10) \).

3.4. Parent ratings of executive function

To investigate the extent to which subtypes differed in parent perceptions of executive function, multivariate analysis of variance (MANOVA) was conducted. Results of the MANOVA were significant (Wilks’ Lambda = .58; \( p = .02 \); \( \eta^2 = .43 \)). Means, standard deviations, and univariate results are provided in Table 5. Examination of the univariate group comparisons on the BRIEF parent ratings yielded significant differences only on the Inhibit subscale, such that the CT evidenced more problems with inhibition relative to the PI group \( (\eta^2 = .19) \). These results remained consistent when the girls were excluded from the analysis and when Full Scale IQ was controlled for in the analyses.

Table 4
Mean scores (S.D.) for executive function domains by subtype

<table>
<thead>
<tr>
<th></th>
<th>ADHD: Predominantly Inattentive (N = 13)</th>
<th>ADHD: Combined Type (N = 27)</th>
<th>F(1, 38)</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibition(^a)</td>
<td>50.82 (8.83)</td>
<td>53.18 (8.54)</td>
<td>1.32</td>
<td>.04</td>
</tr>
<tr>
<td>Planning(^b)</td>
<td>97.62 (13.74)</td>
<td>94.52 (11.33)</td>
<td>.09</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Interference(^d)</td>
<td>43.73 (4.77)</td>
<td>46.94 (7.70)</td>
<td>1.17(^c)</td>
<td>.03</td>
</tr>
<tr>
<td>Set shifting(^d)</td>
<td>3.47 (2.51)</td>
<td>2.34 (2.03)</td>
<td>1.47</td>
<td>.04</td>
</tr>
<tr>
<td>Processing speed(^b)</td>
<td>96.91 (13.56)</td>
<td>100.67 (12.79)</td>
<td>.35</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. ADHD: Attention Deficit Hyperactivity Disorder.

\(^a\) T-score.

\(^b\) Standard score.

\(^c\) With girls excluded, \( F(1, 28) = 5.23; p = .03 \); partial \( \eta^2 = .16 \).

\(^d\) z-Score/ratio sum.
Table 5
Mean scores (S.D.) for BRIEF scales by subtype

<table>
<thead>
<tr>
<th></th>
<th>ADHD: Predominantly Inattentive (N = 13)</th>
<th>ADHD: Combined Type (N = 27)</th>
<th>F(1, 38)</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibit</td>
<td>55.85 (12.07)</td>
<td>69.07 (13.44)</td>
<td>9.06*</td>
<td>.19</td>
</tr>
<tr>
<td>Shift</td>
<td>62.46 (13.59)</td>
<td>62.74 (13.88)</td>
<td>&lt;.01</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Emotional control</td>
<td>59.69 (11.59)</td>
<td>63.11 (13.99)</td>
<td>.58</td>
<td>.01</td>
</tr>
<tr>
<td>Initiate</td>
<td>60.31 (10.52)</td>
<td>63.22 (9.92)</td>
<td>.73</td>
<td>.02</td>
</tr>
<tr>
<td>Working memory</td>
<td>70.77 (6.61)</td>
<td>71.41 (9.99)</td>
<td>.04</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Plan/organize</td>
<td>67.38 (5.39)</td>
<td>69.70 (11.80)</td>
<td>.45</td>
<td>.01</td>
</tr>
<tr>
<td>Organize materials</td>
<td>62.54 (8.32)</td>
<td>63.37 (7.29)</td>
<td>.10</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Monitor</td>
<td>65.85 (9.66)</td>
<td>65.48 (10.70)</td>
<td>.01</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

Note. ADHD: Attention Deficit Hyperactivity Disorder.
* p = .005.

4. Discussion

Whether considered as two distinct disorders (e.g., Barkley, 1997a, 1997b; Milich, Balentine, & Lynam, 2001), or as subtypes of a single disorder (e.g., Lahey, 2001), research continues to support differentiation of PI and CT with some exceptions (e.g., Geurts et al., 2005). As noted by Nigg et al. (2002), these differences may be subtle; further, differences may vary by gender (Biederman et al., 2002; Gaub & Carlson, 1997; Nigg et al., 2002). The nature of these differences, however, remains elusive with research results equivocal.

It has been documented elsewhere that achievement difficulties and attention problems are directly related (e.g., Aaron et al., 2004; Rabiner et al., 2004). Results of this study support previous findings that children with ADHD subtypes evidence somewhat lower achievement than expected based on standardization data, particularly in written language and math areas. Between subtype differences did not emerge, however, in relation to frequency of children within a subtype identified with learning disabilities or in terms of actual academic levels, once ability was included in the analyses. Similarly, no differences emerged with regard to basic expressive and receptive language ability. These findings could be interpreted as indicating that children in both the PI and CT groups were evidencing similar attentional problems that compromised their academic levels to the same extent. Alternatively, the lack of differences may reflect the fact that 31% of the PI group and 78% of the CT group had previously been identified and treated with medication during school hours. Further, for this sample, the majority of children were from families with higher than average parent educational level. Taken together, these factors (medication status, previous diagnosis, and parent educational level) may have diffused any between group differences.

Speed of cognitive processing has garnished much attention in the literature. Results indicated that although academic fluency, particularly in math, was somewhat lower than expected for the PI group, significant group differences did not emerge.

Consistent with the findings of Hynd et al. (1989), results indicate that although there may be some evidence of difference in processing speed, children with either subtype of ADHD cannot be differentiated from each other or controls on specific neurocognitive tasks purported to measure processing speed. Although Nigg et al. (2002) found differences between PI and CT on planning tasks, measures used in this study did not yield significant differences. Similarly, no differences emerged on domains of inhibition or set shifting on laboratory tasks, although parent reports were consistent with expected findings of greater problems with inhibition for children in the CT group. Notably, for the interference domain, when only boys were considered, and cognitive ability was not controlled, boys in the PI group did evidence more problems with interference than boys in the CT group. In summary, these findings suggest that for both PI and CT types, there is the potential for similar neurocognitive and academic processes to be implicated, with more similarities than differences. Treatment, therefore, may need to be determined more idiosynchronically, based on the strengths and weaknesses of the individual, as opposed to the subtype assigned.

Thus, as has been found in other studies, laboratory measures and rating scales often do not yield comparable results (e.g., Muir-Broadus, Rosenstein, Medina, & Soderberg, 2002; Nichols & Waschbusch, 2004; Silver, 2000). This suggests that laboratory measures, while they may add to what is known about the child, do not accurately reflect what others see in daily contexts. Further study, with input from teachers is needed, to assess behaviors in school contexts. In addition, the finding that in some cases results differed depending on the intellectual ability or gender of
the sample raises questions regarding the extent to which developmental and cultural contexts as well as gender need to be considered in the diagnostic process. These findings may help to explain the equivocal findings across research studies and highlight the need for additional research that examines gender differences and limiting (or helping) effects of cognitive ability in the manifestation of ADHD in varying contexts. Additional research is needed in this area.

References


