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ABSTRACT

This paper examines cognitive processing problems associated with attention deficit disorders (ADD) and their relationship to learning disabilities in elementary and secondary students. Children with ADD, medicated (N=20) and unmedicated (N=21), were compared on the Raven test of Progressive Matrices and other tests with children who had been referred for assessment of learning disabilities (LD) and who were either identified (N=16) or not identified (N=11). Discriminant function analyses were conducted to determine the cognitive/educational profile which differentiated among the four groups studied. Grouping nonmedicated ADD subjects with LD subjects proved effective, indicating a need for special education programming appropriate to both groups. The nonmedicated ADD group demonstrated weaknesses in word attack (decoding) calculations and verbal working memory. Similarities and differences among nonmedicated ADD and LD subjects are discussed. Includes 46 references. (PB)

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# The Psychoeducational Link Between Attention Deficit Disorder and Learning Disability

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The Psychoeducational Link between Attention Deficit Disorder and Learning Disability


## Abstract

There has been much debate about whether attention deficit disorder requires special education intervention and whether it should be considered a learning disability. This paper examines the cognitive processing problems associated with attention deficit disorder (ADD) and their relationship to learning disability (LD). ADD children, medicated and unmedicated, were compared to LD children and children who were referred but not indentified (No ID) on the basis of their performance on a battery of tests typically used to determine learning disability. Special use is made of the Raven test of Progressive Matrices. Two discriminant function analyses (DFA's) were conducted in order to determine the cognitive/educational profile which differentiated among the 4 groups in this study: ADD, no meds; LD; No ID; ADD, meds. The first DFA attempted to differentiate all 4 groups. Although classification accuracy was only 69.05% a significance level of p=.0002 was obtained. The second DFA reached a better solution by treating the LD and ADD, no meds as one group. This 3 group solution achieved a classification accuracy of 78.57%, p=.0001. Classification "errors" are discussed. The ADD, no meds group were found to have weaknesses relative to their ability in word attack (decoding) calculations and verbal working memory (Detroit-2, word sequences). Similarities and differences among ADD, no meds and LD's are discussed.

> Symbol Triggering Patterns are the Roots of Meaning...What good would it do a spear thrower to be able to calculate parabolic orbits when in reality there is wind and drag, the spear is not a point mass - and so on? It's quite the contrary: a spear thrower does best by being able to imagine a cluster of approximations of what may happen (and simply taking aim, our words).
>
> Hofstadter, Metamagical Themas, p. 650.

Achieving an understanding of attention deficit disorders (ADD) has been difficult, realizing the relationship between ADD and learning disability has been even more challenging. The boards of experts who have created DSM's I through III-R and who have now nearly created DSM - IV have demonstrated the elusiveness of the concept with certainty in the form of ever-changing definitions, subcategories and reformulations. The confusion seems to come from everywhere: what is the difference between biochemically determined temperament (Kagan, Reznick and Sneidman, 1987) and ADD, where does one begin and the other end; what are the cognitive correlates of attention, how do they effect learning and when does it all circumscribe a learning disability; what is the relationship between the neurological substrates of ADD and pharmacological intervention (Davy and Rodgers, 1989); what is the essence of the disorder, is it attention, impulsivity, hyperactivity; where do underfocusing and overfocusing fit in, similarly what about passivity. This is enough to make the point but there is plenty more. The overriding, persistent (if unfortunate) conclusion has been to conceptualize ADD's as representing "Disruptive Behavior Disorders" (DSM III R, 1987). It is our view that focusing on disruptive behavior is a narrow, though convenient, strategy which puts the accent on the wrong syllable. Despite the increasing awareness that cognitive issues of attention are central to the understanding, diagnosis and treatment of ADD (August and Garfinkel, 1989; Tannock, Schachar, Carr and Logan, 1989; Felton and Wood, 1989), diagnostic criteria continue to emphasize behavioral issues.

Our concern has to do with all of this but primarily with deriving a template (Brooks, 1978), a core concept (Fodor, 1988) or a prototype (Rosch, 1973) of attention deficit disorder.[1] In keeping with approaches to "commonsense psychology" (Fodor, 1988) of this kind, we do not propose to derive an algorithm for computing the presence or absence of ADD. We do not propose solely to test the null hypothesis. And we neglect to do so out of conviction. We find it most informative and clinically useful to describe most cases and, ideally, core cases. As in the case with all concepts and even algorithms, defining the positive and negative instances at the fringes is just plain impossible.

We set out, then, to derive an imperfect or, perhaps better said, noncomputational, conceptualization of what ADD is and how it effects learning in the school environment. By virtue of its imperfection, we believe our conceptualization is more likely to recognize the range and variability of suitable cases and avoid the more unsuitable ones than a more formalistic approach which fails to notice subtleties, or varying relationships among contributing factors, or the need for shifting weightings due to environmental issues, other biological ones, etc. (Medin, 1989). Our position is that the central problem for people with an attention deficit disorder is the way they process information, the way they perceive and then make sense out of the world. Since attention is a part of this much larger, information processing, cognitive system which in turn is part of an even more intricate neurological, intrapersonal, interpersonal, educational and familial system, the effects of a disorder in attention are bound to be pervasive.

At the same time there has been some concern both at the policy level and at the conceptual level about the relationship between attention deficit disorders and learning disabilities. If one makes the assumption that the central problem in attention dysfunction is just that, attentional, then ADD becomes a cognitive/learning problem with clear implications for learning disability. In fact, a large degree of overlap has been found between the learning disability and the ADD populations (August and Garfinkel, 1989; Cantwell and Satterfield, 1978; Lambert and Sandoval, 1980). A good deal of debate has centered around issues of primacy of dysfunction. It has been argued that if attention is the primary dysfunction, learning problems are secondary. If a learning disability is primary, attention problems can result (Felton and Wood, 1989). This does not seem to be a fruitful line of debate. It is highly likely that attention problems are simultaneously and systemically correlated with learning problems, that problems in learning create a higher demand on attentional processes, and that problems in attention have direct effect on learning. Some work has suggested to us that primacy is irrelevant even in the decision to prescribe stimulant medication (Davy and Rodgers, 1989).

We have been interested in delineating the cognitive difficulties associated with attention deficit disorder and their impact on school learning. The cognitive view places attention (or for that matter, any other cognitive process) within the context of a reverberating cognitive system in which processes are not conducted either in isolation or in any unidirectional sequence (Hofstadter, 1985). Attention thus impacts the rest of the system by what information it allows in at the sensory level, by what information it can retrieve and manage at an internal, memorial level (Enns and Akhbar, 1989), for how long and at the exception of what other information, and is also impacted by other cognitive processes. The complexity of the role of attention in the larger cognitive system has been recognized. Neuropsychological studies of attention have traced the course of attentional processes through areas of the brain associated with tonic arousal, mood and focus regulation and executive function (Trexler and Zappala, 1988). The critical relationship between attention and working memory has also been emphasized. The traditional ACID profile is comprised of 4 WISC-R subtests two of which are, in large part, measures of intensive working memory: arithmetic and digit span (Lezak, 1983).

The concept of attention itself is multifaceted. When the notion of a complex attention mechanism is embedded in an even more intricate, larger cognitive system, the result has been more complicated than we can know. In the effort to understand the impact of attention disorders on school performance we have focused on the relationship between working memory and attention (deSonneville and Njiokiktjien,

1988) and on the control of attention functions which include aspects of executive function (Shankweiler and Crain, 1986; Baddeley and Hitch, 1974). The limitations of working memory capacity place pressure on attentional mechanisms to be highly tuned and efficiently paced so as not to overload or underestimate capacity. It is now widely accepted that working memory is a two part system consisting of short term memory, the capacity for immediate recall; and of the executive component, the metaoperation or control center for the management of information in working memory (Case, 1985; Torgesen, Kistner and Morgan, 1987).

Executive functions enable the control and development of attention. It needs to be emphasized that attention serves working memory and is served by it, not just in the collection of data "out there", but also in the retrieval of data from the knowledge store for the purpose of internal, memorial manipulation or just plain thinking, planning or organizing. And, attention must be deployed among "out there" data and "in here" data in order to make any kind of sense at all.

Lack of cognitive control, then, has a considerable impact on attention-working memory processes. The active, controlled focus of attention is implicated whenever symbol learning is at issue. Since, in these situations, there is no inherent, contextual meaning, associations need to be made arbitrarily. Incorporating this kind of information requires the cooperation of active, controlled attention and working memory along with strategy production (Cherkes-Julkowski and Gertner, 1988). If the attention-retention (Zeaman and House, 1979) system is faulty, problems are likely to show up whenever the learning of symbols or of other formalized information is necessary. In school these include: skills for decoding in reading (Halperin, Gittleman-Klein, and Rudel, 1984), skills for calculation in math including automization of number facts and of algorithms. Later, problems might appear in algebraic procedures and in written discourse. A review of recent literature concerned with academic functioning and ADD reveals that very little attention has been given to effects on math calculation or problem solving (August and Garfinkel, 1989; Richardson, Kupietz, Winsberg, Maitinsky and Mendell, 1988; Kupietz, Winsberg, Richardson, Maitinsky and Mendell, 1988). Furthermore, reading is measured using real words which might have been taught specifically and can thus have been read correctly without reflecting an understanding of the principles of decoding. Since it is deriving the arbitrary rules for decoding and performing the working memory aspects of phonological analysis which are not only critical to reading (Liberman and Shankweiler, 1987) but which are implicated in attentional dysfunction, the inclusion of a pure decoding task is essential. Pseudowords are the only way to test this directly (Torgesen, 1989).

Limited attention can impair cognitive function by curtailing thought processes either directly or indirectly through the executive function mechanism. The direct effect of unsustained attention is that the child simply cannot carry a thought all the way to the last implication or final conclusion. Likewise, the child might be cut off from collecting all the relevant information needed to think. Difficulty with executive function results in difficulty with orchestrating multiple-step or complex thought processes in a synchronous manner. In this case what is at issue is the ability to manage information, to take in just enough, store it, take in more, compare it with the stored information and to continue this juggle as well as the monitoring of what has been done thus far and the awareness of what the goal of it all continues to be. This responsbility rests within the executive function/working memory complex. A dysfunction here is likely to manifest as impulsivity or short attention span. What is happening seems to be cognitive overload which causes the child to cope (in self-defense) thus resulting in disruptive or negative behavior or in shutting down.

Regardless of the source, attention is curtailed either wittingly or unwittingly and the systematic collection and management of information suffers. This kind of problem is likely to have a pervasive effect on learning, social interaction and everything else. The school (and extra-curricular, e.g. social and personal) manifestations are likely to be everywhere and to need consistent management. Clinically we have come to expect manifestations in the areas of math problem solving and reading comprehension where the construction of mental models independent of the form of information presentation is necessary (Johnson-Laird, 1983, Carlisle, 1989). In pursuit of this idea we have adapted a position set forth originally by Budoff and Corman (1976) and Feuerstein, Jensen, Hoffman and Rand (1985). We have hypothesized that the problems children with ADD have with complex reasoning can be alleviated at least in part by directing and controlling their attention to all the problem information in a carefully paced manner. We call this prompting but it consists of no substantive or procedural information, merely the systematic, regularly paced pointing to each component of the problem to be solved.

In this study we have set out to see if the predicted pattern holds up. We have posed the following questions:

1. Are children with attention deficit disorder (ADD's) who are not taking medication (ADD's, no meds) similar to children with learning disabilities (LD's)? Are there any differences? If so, what are they?

2. Do children identified as ADD have a profile consisting of low working memory scores? In the presence of low working memory scores are there also low scores in word attack (decoding) and calculation?

3. Is the above suggested pattern different when a child has been medicated vs when s/he has not? To what degree and on what aspects of functioning does medication have effect?

4. Does the prompting or redirection and controlling of attention assist children with ADD? Does prompting differentially effect the performance on a test of abstract reasoning of children with ADD, medicated; ADD unmedicated; LD and children who have been referred but not identified (NoID)?

5. Is there a correlation between the effect of prompting and performance in measures requiring information management/mental model construction which, in this study are measures of math problem solving and reading comprehension?

6. Can children with ADD, medicated and unmedicated, be differentiated from those with learning disability (LD) and those who have been referred but not identified (NoID) based on the profile proposed?

Methodology

<u>Subjects</u>. All subjects in this study were referred to one or both of the first two authors (a developmental, behavioral pediatrician/psychotherapist and a special educator) due to concern about an estblished disorder or set of disorders or due to a suspicion of: (1) learning disability; (2) attention deficit disorder; (3) emotional problems (depression, low self-esteem, anxiety, low

motivation); or (4) behavioral concerns (i.e. acting out). These categories were not mutually exclusive in the population. It is important to note that even those children who were not identified as a result of our evaluations were, in fact, a cause of some concern to the referring agent. Cases were referred by parents, family therapists, pediatricians, pediatric neurologists, psychiatrists and school systems.

Four groups of children were identified: (1) attention deficit disorder, unmedicated (ADD,nomeds); (2) not identified as having any handicapping condition (NoID); (3) learning disabled (LD); and (4) attention deficit disorder, medicated (ADD,meds).

Children were classified as LD for the purpose of this study based on their performance on the test battery described in the procedures section as well as on information provided by the school, i.e. concerns about school performance, previous identification. In order to be identified as LD the criteria set forth by the guidelines for PL 94-142 were used: achievement significantly below expectancy (1.5 standard deviations or 50% below expected grade level functioning) and the presence of a processing problem as defined by a significant discrepancy among processing abilities (1.5 standard deviations). An examination of the battery described below indicates that a cognitively based source of LD is emphasized rather than a more purely perceptually-based view.

The diagnosis of ADD was made by either a developmental pediatrician, pediatric neurologist or psychiatrist. All physicians based diagnosis on a combination of home and school behavior ratings and developmental history. All diagnoses were made in conjunction with adherence to the DSM guidelines which were operative at the point of diagnosis. Due to the difficulty in making definitive diagnoses of ADD and the fluctuating DSM criteria as well as the natural heterogeneity found in any diagnostic category of handicapping condition, the ADD subgroups in our study reflect the variability which exists among the subtypes of ADD's (Newcorn, et al 1989, August and Garfinkel, 1989; Coleman and Levine, 1988, Phillips, 1989, Shaywitz and Shaywitz, 1988).

Of the ADD sample, 20 who were receiving medication at the time of the office visit and thus at the time of evaluation, were clearly already identified. The 21 who were not on medications were identified as a part of our diagnostic procedures. Although dosage levels (mg/kg) for all those children taking medication were different, and although not all were taking the same kind of medication (methylphenidate, dextroamphetamine, pemoline and desipramine or imipramine were the kinds of medications which were prescribed), some children already on medication had been assessed as having reached a steady-state, adequate kind and level of medication for all aspects of school, social and familial functioning while minimizing side effects. Medication kind and level were selected with the entire functioning of the child in mind including emotional issues and mood regulation.

Other children may have been just starting a medication trial when cognitively evaluated. Multi-level interventions were already in place for many of the children, including special education; classroom modifications; individual and family cognitive, behavioral and psychotherapy.

The population in its heterogeneity of type, subtype and treatments is representative of the characterics and treatments in the general population.

Distribution of subjects across sex, grade, ability measure and special education services at the time of clinic entry is reported in Table I.

Insert Table I about here

Procedure. In-take information was collected for all subjects including developmental history, present parental and school concerns, and a review of existing records. Each child was evaluated in a one-to-one situation for a testing period of approximately 2 hours. A battery of tests was selected to measure the areas hypothesized to be affected by attention. A similar battery has been used in a recent study of educational problems related to ADD (August and Garfinkel, 1989). The following battery was administered to all subjects in the order listed:

1. Woodcock-Johnson Psychoeducational Battery, selected subtests: Word Attack, Passage Comprehension, Calculation and Applied Problems;

2. Raven Test of Standard Progressive Matrices

3. Detroit Tests of Learning Aptitude - 2, selected subtests included: Word Opposites, Sentence Imitation, Word Sequences, Object Sequences and Conceptual Matching

The battery was selected to tap specific processes. Word Attack was chosen because it consists only of pseudowords and, thus, can measure phonemic awareness (Maclean, Bryant & Bradley, 1987; Perfetti, Beck, Bell and Hughes, 1977; Vellutino & Scanlon, 1987; Mann, Tobin & Wilson, 1987; Ehri, Wilce and Taylor, 1987) which has been found to be essential to the reading and spelling process. The cloze task used in the passage comprehension test provides a relatively stringent measure of decoding and comprehension since the passages are short and provide little redundancy or familiar information. Math computations were measured in the calculation task. Since the test was untimed, judgments about automaticity of number facts are not reflected in the calculation score. Applied problems measures verbal problem solving. The task allows for the reading of problems to the child and thus avoids math or reasoning "errors" due to faulty reading.

All tests were administered untimed. For all achievement tests a grade equivalent was determined and then a ratio computed based on the formula: grade equivalent/grade placement. Although standard scores might have been more precise psychometrically, this population was tested at a time when separate scores for each of the individual achievement ~~areas~~ mentioned (word attack, passage comprehenension, calculation and applied problems) were reported only as grade level scores (McGrew and Woodcock, 1985).

The Detroit test of word opposites was used to assess verbal ability as well as to collect clinical data concerning word retrieval and semantic store. Conceptual Matching was designed to tap concept formation in the absence of demands for language production. Since the task requires choosing an answer from among ten choices, some need to inhibit impulsive responding is built into the task. Sentence Imitation, Word Sequences, Object Sequences are measures of verbal working memory. Sentence Imitation provides the organizing features of language as children are asked to repeat sentences. Word Sequences require attention to disconnected, strings of words in order to repeat them in exact sequence. Although the object sequences task uses pictures to be remembered, it differs from the more obviously verbal working memory measures in ways other than the presence or absence of visual input. All pictures are linguistically codable (Liberman and Shankweiler, 1987). They require rapid access to labels, a feature often lacking in children with language-based learning disability. Children are asked to view the string of pictures for a given amount of time. They do not have the advantage of administrator given stimuli and thus might not pace themselves well enough to cover all of the stimuli before time is up. Or, children might be advantaged by the opportunity to self-pace information intake. The response requires recognition memory rather than free recall. There are other differences as well. Our point is that there is little value in focusing on the visual-auditory distinction among these working memory tasks as the critical one.

The Raven was selected as a measure of abstract reasoning ability as well as a tool for observing cognitive style.

Although the Raven appears to be a test which depends on spatial reasoning, PET studies have established that a good deal of processing in the effort to solve Raven problems is done in the left temporal and frontal lobes (Haier, Siegel, Nuechterlein, Hazlett, Wu, Paek, Browning & Buchsbaum, in press) and thus can implicate language and executive functioning as well. The Raven was administered in standard format as well as under a verbally prompted condition. The prompted condition is modelled after Budoff and Corman's (1976) and Feuerstein's (1985) dynamic assessment techniques. Prompts were designed to focus the child's attention on all aspects of the problem by stating "watch me" and pointing to each cell of the matrix or asking the open-ended question, "Why did you pick that one?". Prompts were administered directly after the standard administration of an item. Prompts followed correct as well as incorrect answers.

Method of Analysis. Our approach to capturing the essence of ADD as well as differentiating among the 4 subgroups has been based on uncovering likely patterns of cognitive and academic performance which emerge within each of the 4 groups and which can be used to discriminate among them. We have begun by theorizing about which cognitive processes and academic areas would be affected most prevalently by attention dysfunction and then set out to see if it were so. The circularity of this approach is evident but essential. In the process of developing a concept of ADD and perhaps clarifying concepts of ADD and LD it is necessary to create a frame from which to view them. The frame of course creates its own bias. But in the words of Karmiloff-Smith and Inhelder (1974/75), "If you want to get ahead, get a theory".

## RESULTS

### Cognitive/Educational Profile of ADD

Mean scores for the 4 groups of subjects were used to describe the pattern of cognitive and educational performance of each group: ADD, no meds; ADD, meds; NoID, LD. Table II reports

Insert Table II about here

means and standard deviations. The children who have ADD and who are unmedicated have the lowest scores in nearly all achievement and processing areas. At the same time, ADD's, no meds have the highest Raven ratio score. Since the Raven ratio is calculated by dividing the prompted by the unprompted score, a higher number indicates a greater increase under the prompted condition and thus a greater effect of prompts. The LD word attack ratio score is lower but cannot be considered significantly different from ADD's with or without medications.

Two discriminant function analyses (DFA's) were conducted in order to determine the cognitive/educational profile of children with ADD in comparison to the other groups in the study. A major question in this study has been the relationship between ADD and LD. The first DFA attempted to differentiate the following 4 groups: ADD's with and without medication from the LD group as well as the NoID's. The second analysis was performed to determine whether a more discriminating solution could be obtained if the ADD, no meds group and the LD group were combined. The results of both analyses are reported in Table III. The DFA's selected

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Insert Table III about here

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similar discriminating measures. All of the measures with the exception of passage comprehension ratio were identical in both analyses. Passage comprehension in the 4-group approach was utilized to discriminate between the ADD's, no meds and the LD group. The means, for all measures, can be found by referring back to Table II. An examination of the means indicates that the ADD's, no meds performed more poorly on passage comprehension than the LD's despite a highly similar word attack ratio score.

The more efficient solution and the one more capable of accurate discrimination among groups was the one which regarded children with ADD and with LD as belonging to the same diagnostic category in terms of educationally related performance. Both the 4-group and 3-group classification results are reported in Table IV. In the 3-group solution

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Insert Table IV about here

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where ADD, nomeds and LD were combined, the source of classification error is to a very large degree due to the "misclassification" of the referred but unidentified group. When the DFA was designed to discriminate among the original 4 groups, the function tended to recognize NoID's as LD and tended to "err" in classifying nearly 50% of the LD group as ADD's: 33% as ADD,no meds; 11% as ADD,meds. In the 3-group solution, the largest percentage of misclassified NoID cases were predicted to belong to the combined ADD, no meds/LD group. Few errors are made in either DFA in interpreting either ADD's or LD's as nonhandicapped (NoID).

The prediction accuracy is idiosyncratically diminished when the 3-group solution is used only in the case of the

NoID's. An examination of the means indicates that on object sequences, conceptual matching and passage comprehension, the NoID group falls between the ADD, no meds and LD groups. In these cases the LD group is the highest. When scores for the lowest, ADD, no meds, and highest, LD's, are combined, the effect is to approximate the level of NoID scores and cause classification error.

A look back to Table I will confirm the fact that there is a confound between medication and special education intervention. Table V reports the means on relevant scores for the ADD, meds group broken down into those who have

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Insert Table V about here

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received special education services and those who have not. Means indicate that the ADD, meds cases who have not received special education services are performing in the superior range on tests of vocabulary (word opposites) and concept formation (conceptual matching).

Prompting Effects

Regressions were run separately for each of the original four diagnostic categories to determine the correlates of the Raven raw score ratio (prompted raw score/unprompted raw score). Results of the analyses appear in Table VI. In the

ADD, no meds group the strongest correlate of improvement

Insert Table VI about here

under the prompted condition was a measure of working memory, word sequences. It should be noted that both of the other working memory measures were moderately correlated: sentence imitation, r=-.38; object sequences, r=-.38. Negative correlations indicate that the lower the working memory score, the greater effect of prompting (redirecting attention) on a reasoning task. In the NoID group the calculation ratio was highly and positively correlated with the Raven raw score ratio. Once the shared variance with calculation ratio is accounted for, the working memory measure was entered. The highest correlation with the criterion variable in the LD group was object sequences. A low score in the latter was related to a greater prompting effect. In the ADD, meds group, the highest correlation with the Raven raw score ratio was a measure of math problem solving, again negatively correlated.

## DISCUSSION

Our concern has been the derivation of an educationally and cognitively based concept of ADD and its relationship to what we have come to know about learning disability. We have found that children with untreated ADD, those who have not been prescribed medication and only a very small percentage of whom have been prescribed special education intervention, to be difficult to differentiate from other forms of learning disability. The similarity in performance makes no claims about similarity of source of learning disability in the two groups. Theoretically one set of problems is driven by the implications of dysfunction in aspects of attention, the other by language-based processes, among them rapid naming, phonological/linguistic awareness. More will be said about these underlying dynamics in the discussion of correlates of the Raven prompted score. For now it is important to recognize that discriminant function analysis generated a more accurate solution when the ADD's, no meds and LD's were considered as one diagnostic category. Furthermore, if the DFA is instructed to consider the ADD, no meds and LD groups as independent, a high percentage of "misclassification" occurs by identifying one group as the other rather than misclassification into the remaining two diagnostic categories.

The ADD, no meds group can be characterized by weakness in working memory and pervasive achievement problems. Word attack and calculation scores are highly similar to those in the LD group. In the LD group, however, these achievement difficulties seem relatively contained. Some compensatory processes must be operative in order for the LD's to access meaning in reading comprehension and to be able to solve verbal math problems despite relatively low scores in the underlying skills required. The ADD's,no meds, however, decrease in performance level when additional demands are made for more extensive processing such as the reorganization of problem information and/or mental model construction. The ADD, no meds child appears to be vulnerable at many points of attention: effortful, controlled focus and processing which is generated in working memory for the purpose of symbol learning in reading (decoding) and math; sustained attention to all relevant, external information required for reading comprehension or math problem solution; and sustained attention to internal information processing especially when reorganizing and mental model building are implicated. As the task requires more of the points of vulnerability, ADD, no meds', performance decreases. At the same time, lack of skill fluency caused originally by problems in focused, effortful processing/working memory aspects of attention introduces an additional burden in the form of the need to attend to basic skills at a conscious and effortful level (Enns and Akhtar, 1989; Schiffrin and Dumais, 1981). The attention problem, thus, has a way of coming back upon itself.

This must be confusing to teachers, parents and to the child. When a child confronts any one these challenges in isolation, s/he is likely to be able to marshal the resources to meet it. When the same task is embedded with other attention stressors, the child simply lacks the resources to go on. The giving up (acting out, bursts of temper, signs of frustration) or shutting down (passivity, learned helplessness, quitting) certainly look like problems in motivation which are likely to suggest themselves as the "real" source of the problem. When viewed from the perspective of attention dysfunction, they are seen as efforts at coping with ever mounting and increasingly insurmountable attentional demands.

For any underlying processing disorder to manifest itself as a learning disability, there must be a discrepancy between ability and achievement. The question of measuring ability in a learning impaired population has plagued the field of special education (Siegel, 1989; Stanovich, 1989). It has been argued, and argued well, that measured IQ tends to be an underestimate in a learning impaired population (Siegel, 1989). Particularly when attention is impaired, the validity of the test procedure comes into question. In the selection of the Raven Standard Progressive Matrices and by using a prompted condition we have tried to avoid the worst of the problems for our ADD and LD populations: failure to have acquired information incidentally or otherwise and failure to attend well enough to produce valid demonstration of reasoning ability. The Raven has been recognized as the test with the highest correlation with general ability (Jensen, 1982). It is not dependent on specific, previously learned information. Despite the fact that it appears to require right brain based spatial reasoning, PET studies (Haier, et.al., in press) have indicated the implication of left temporal language and frontal areas in the advanced items. The Raven does not appear to be, then, a test of a specific processing ability. The prompted condition allows for the correction of limited attention and thus a more direct measure of reasoning ability. The use of the Raven prompted score seems to be a valid procedure for identifying potential or expected level of functioning. At the same time the magnitude of the increase in score in the prompted over the unprompted condition reflects the degree to which poorly controlled attention is a problem.

The use of the prompted Raven score as an ability index in our study has yielded mean ability scores which are similarly high for all groups. "Poor" academic performance needs to be considered in the light of these high average, nearly superior ability scores.

The ADD's,no meds can be differentiated from ADD's,meds. Very little error is made in either of the DFA's in classifying these subgroups. None is made in the 3-group solution. Some gains are found in nearly all measures when ADD's,no meds are compared to their medicated counterparts. It must be emphasized, however, that medication does not exist as an isolated phenomenon. Table I confirms the fact that a high percentage of children receiving medication also receive special education services. Seeking, monitoring and reliably administering medication requires some commitment and organizational competence on the part of the family. All of these factors must be considered in interpreting "medication effects". In our population those who are medicated but not receiving special education are brighter and younger. It is likely that they simply have not yet "hit the wall".

Despite the increase in performance in the medicated over the unmedicated group of ADD's, the score in word sequences, the measure of working memory, remains relatively low when compared to other processing scores in the ADD,meds group. The most stringent measure of controlled in-take and management of out-of-context information remains impaired even with medication. This suggests a need for intervention beyond medication alone. It is encouraging to find, however, that the effects of prompts has diminished in the medicated group. The implication is that the children taking medication are no as longer dependent on external prompts to demonstrate their reasoning potential.

One purpose of this study was to attempt to examine the relationship between the effect of prompting and other educational/cognitive processes. Prompting does in fact result in a higher reasoning score for all groups. The ADD,no meds group is helped the most.

The correlates of the Raven Ratio are different for each group. As we predicted, ADD's,no meds display the strongest relationship between the most demanding working memory task and the effects of prompting. The lower the capcity for working memory, the greater the assistance provided by prompts. In the LD group there appears to be a relationship based, possibly, on the processing of visually presented information. This is not to identify the construct as visual information processing. Although both the Raven and its correlate in the LD group, object sequences, use pictured stimuli, both involve linguistically codable information (Liberman and Shankweiler, 1987) and both require the integration of a large amount of information within and across modalities. These are sources of processing dysfunction often associated with specific, language-based learning disability (Liberman & Shankweiler, 1987; Cherkes-Julkowski & Gertner, 1988). A similar difference between processing profiles of specific learning disability and ADD subjects was reported by Felton and Wood (1989).

In the ADD, meds group the difficulties associated with working memory appear to be controlled through medication (see the means in Table II). Once working memory can be managed, in this way, the relationship between Raven prompting and another measure of reasoning, applied problems, emerges. Similarly, the relationship between working memory and the Raven prompting in the NoID group is secondary. The fact that working memory problems tend to surpress the measure of reasoning ability argues further for the use of a prompted, noninformation based measure of intellectual ability especially in ADD populations.

Implications for Intervention

Our findings indicate the need for programming for children with ADD, particularly those who are unmedicated. Attention dysfunction tends to have an impact on working memory which is implciated in all cognitive effort beyond the most basic. The effects of working memory/attention processing problems are even more pervasive than one finds in a specific learning disability population. The need for special education intervention and mainstream modifications is clear. Despite the higher scores in academic and most processing areas in the ADD,meds group, it must be remembered that a great many of these children were simultaneously receiving special education services. Those who were not may have gone unnoticed simply because their ability levels were higher. It is very difficult to recognize a significant ability-performance discrepancy when intellectual ability appears supressed by attention and performance is at or slightly above grade level. There is, however, sufficient reason for concern about academic functioning to have prompted the referral to our practices.

In our study the functioning of ADD's,no meds and LD's is better conceptualized as belonging to a single diagnostic category. The implication is that both need special educational programming. Correlational analyses suggest, however, that functioning levels are generated by an organization of abilities and disabilities which is qualitatively different in the 2 groups and might, therefore, require different kinds of intervention.

It is clear that attention deficits can impact one child in a variety of ways and can manifest itself across children in various ways. The manifestation of ADD is likely to be a consequence of the intelligence of the child, previous prevention of academic lags or lack thereof, prompting function of the educational and social context, specific interventions, family style personality development, concomitant diagnoses and a host of other variables. Across all age groups in our study, into senior high school, ADD has educational manifestations and creates the need for intervention. We have tried to tie some of these needs together with a suggestion of how attention dysfunction affects thinking and learning. In the words of Medin (1989):

> "...it is clear that the DSM-IIIR guidebook (American Psychiatric Association, 1987) provides only a skeletal outline that is brought to life by theories and causal scenarios underlying and intertwined with the symptoms that comprise diagnostic criteria( p. 1480)."

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FOOTNOTE

[1]We have chosen the term attention deficit disorder since it places the emphasis on the attentional, cognitive component rather than on behavioral/hyperactivity issues.

Table I

Sex, Grade and Educational Intervention Characteristics of the Sample

| | ADD no meds | NoID | LD | ADD meds |
|---|---|---|---|---|
| SEX | | | | |
| Female | 8 | 7 | 5 | 3 |
| Male | 13 | 4 | 11 | 17 |
| Grade | | | | |
| 1-2 | 5 | 1 | 1 | 3 |
| 3 | 5 | 3 | 4 | 6 |
| 4-5 | 2 | 2 | 2 | 5 |
| 6-8 | 3 | 2 | 5 | 5 |
| Senior High | 6 | 3 | 4 | 11 |
| Special Education Intervention | | | | |
| No | 18 | 11 | 9 | 6 |
| Yes | 3 | 0 | 7 | 14 |
| Mean Raven, prompted* | 73.14 (29.99)** | 82.77 (14.50) | 74.93 (23.72) | 76.10 (24.27) |

*scores are percentiles

**numbers in parentheses are standard deviations

Table II
Means and (Standard Deviations) for Cognitive and Educational Measures

| | ADD no meds | NoID | LD nonADD | ADD meds |
|---|---|---|---|---|
| word attack ratio* | 1.14 (.62) | 2.12 (1.18) | 1.03 (.74) | 1.78 (.41) |
| passage comp. ratio* | .98 (.30) | 1.60 (.68) | 1.35 (.55) | 1.44 (.67) |
| applied prob. ratio* | .98 (.38) | 1.43 (.23) | 1.16 (.26) | 1.16 (.27) |
| calculation ratio* | 1.06 (.41) | 1.44 (.58) | 1.01 (.16) | 1.11 (.19) |
| word opposites** | 9.50 (3.13) | 12.00 (1.63) | 11.85 (2.54) | 12.00 (2.00) |
| sentence imitation** | 9.30 (3.59) | 12.85 (2.26) | 10.00 (3.46) | 10.25 (2.31) |
| word sequences** | 7.10 (3.07) | 11.85 (1.34) | 8.28 (1.60) | 9.37 (3.15) |
| object sequences** | 9.40 (3.50) | 12.57 (3.40) | 13.00 (3.05) | 10.00 (2.77) |
| conceptual matching | 8.10 (2.80) | 9.71 (1.49) | 10.57 (2.43) | 12.75 (2.49) |
| Raven Ratio*** | 1.98 (2.13) | 1.19 (.18) | 1.24 (.11) | 1.26 (.19) |

*grade score/grade placement

**standard score with a mean of 10, standard deviation of 3

***percentile score for prompted raven/percentile score, unprompted

Table III

Measures Selected by DFA's to differentiate among groups

| DFA based on 4 groups: ADD,no meds, NoID, LD, ADD,meds | | | DFA based on 3 groups: ADD,nomeds/LD, NoID, ADD,meds | | |
|---|---|---|---|---|---|
| Measure | Wilks' Lambda | significance | Measure | Wilks' Lambda | significance |
| word sequences | .6490 | .006 | word sequences | .6697 | .003 |
| object sequences | .4769 | .002 | conceptual matching | .4760 | .0003 |
| conceptual matching | .3012 | .0001 | object sequences | .3947 | .0002 |
| word attack ratio | .2374 | .0001 | word attack ratio | .3127 | .0001 |
| passage comprehension ratio | .2049 | .0002 | calculation ratio | .2524 | .0001 |
| calculation | .1596 | .0002 | | | |

## Table IV

Two Discriminant Function Analyses (DFA's) testing the Distinctiveness of an ADD, unmedicated and an LD group

| Actual Group | Predicted Group Membership | | | | | | |
|---|---|---|---|---|---|---|---|
| | DFA: 4 groups | | | | DFA: 3 groups | | |
| | ADD no meds | LD | NoID | ADD meds | ADD/LD | NoID | ADD meds |
| ADD, no meds | 69.2 | 7.7 | 7.7 | 15.4 | | | |
| | | | | | 90.9 | 0 | 9.1 |
| LD | 33.3 | 55.6 | 0 | 11.1 | | | |
| NoID | 0 | 22.2 | 66.7 | 11.1 | 33.3 | 44.4 | 22.2 |
| ADD, meds | 9.1 | 9.1 | 0 | 81.8 | 18.2 | 0 | 81.8 |
| Overall classification accuracy | | 69.05 | | | | 78.57 | |

All numbers are percents

Table V
Means and Standard Deviations for Cognitive and Educational Measures for ADD,meds with and without Special Education

| | ADD,meds no special education | ADD,meds special education |
|---|---|---|
| word attack ratio* | 1.81 (.34) | 1.75 (.48) |
| passage comprehension ratio* | 1.99 (.67) | 1.11 (.45) |
| applied problems ratio* | 1.41 (.18) | 1.01 (.20) |
| calculation ratio* | 1.25 (.11) | 1.02 (.18) |
| word opposites** | 13.33 (.57) | 11.20 (2.16) |
| sentence imitation** | 9.80 (2.64) | 10.46 (2.28) |
| word sequences** | 8.20 (4.50) | 8.96 (1.64) |
| object sequences** | 10.33 (5.03) | 9.80 (.83) |
| conceptual matching** | 15.33 (2.08) | 11.20 (.83) |
| Raven Ratio*** | 1.06 (.01) | 1.39 (.13) |
| Grade | | |
| 2 | 2 | 1 |
| 3 | 1 | 5 |
| 4 | 1 | 1 |
| 5 | 0 | 2 |
| 6 | 1 | 0 |
| 7 | 1 | 2 |
| 8 | 0 | 1 |
| 9 | 0 | 1 |

* grade level/grade placement
** standard scores have a mean of 10, standard deviation of 3
*** raven percentile score prompted/ raven percentile score unprompted

Table VI
Regression of Cognitive and Achievement Measures onto Raven Raw Score Ratio by Diagnostic Category

| | simple r | mult R | R | Adj R | F | df | p |
|---|---|---|---|---|---|---|---|
| ADD, no meds | | | | | | | |
| word sequences | -.57 | .57 | .32 | .29 | 9.24 | (1,19) | .006 |
| NoID | | | | | | | |
| calculation ratio | .77 | .77 | .59 | .55 | 13.26 | (1.9) | .005 |
| word sequences | -.43 | .88 | .78 | .73 | 14.57 | (2,8) | .002 |
| LD | | | | | | | |
| object sequences | -.52 | .52 | .27 | .22 | 5.33 | (1,14) | .03 |

ADD, meds
no variables entered
highest correlation with Raven raw score ratio is Applied Problems ratio, r=-.37, p=.05