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Auditory verbal memory acquisition in children 7 to 11: An analysis of acquisition, intrusion errors, and false positives over trials

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AUDITORY VERBAL MEMORY ACQUISITION IN CHILDREN 7 TO 11: AN ANALYSIS OF ACQUISITION, INTRUSION ERRORS, AND FALSE POSITIVES OVER TRIALS

A Thesis

Presented to the

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In Partial Fulfillment

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in

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by

Jane Louise Mathews

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ABSTRACT

School-aged children spend much of their time in a controlled learning environment (i.e., school). Such an environment can be mirrored by studying auditory verbal memory. Archival data from an out-patient sample of children aged 7 to 11 years (N = 50) were utilized to explore acquisition, intrusion errors, and false positives from scores on the Auditory Verbal Learning Test (AVLT, Rey, 1964). Primary results show 3 main findings. First, compared to those with a low mental age (i.e., an age-equivalent score of cognitive or intellectual functioning less than the subject's chronological age), children with a high mental age recall and recognize more words in a learning task. Second, children who recall many words from a learning task produce few memory errors (i.e., intrusions) during that task and 30 minutes later. Third, children's performance during the first learning trial is indicative of later performance. Specifically, children who recall many words at the beginning of a learning task recall many words at the end of the task, and children who produce many memory errors at the beginning of a task also produce many errors at the end of the task. Analysis of the AVLT suggests avenues for targeting children with learning problems and for developing appropriate remedial academic programs. Some of these avenues are discussed.

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INTRODUCTION

School-aged children and adolescents (5-18 years) live in an environment bombarded with the challenges to learn new vocabulary, concepts, and information. In both the social and school setting, there is a demand to acquire and retain an ever-increasing amount of knowledge.

Since children spend much of their time in the classroom, they must become adept at distinguishing relevant, or important, information from irrelevant information. As these children are exposed to successive days of lectures, where each lecture builds upon points from the previous lecture, they must continually reorganize the relevant information in memory.

One way to study this successive learning process is by studying auditory verbal (AV) memory in a controlled, word-list setting. However, before further examining AV memory, one must first look at the components of basic memory theory and how these components work within auditory verbal memory.

Overview of Memory

Researchers have concluded that memory and verbal skills increase with age. More specifically, children's memory span, or the number of items one can recall at a given time, increases throughout development (Kail, 1990). Memory skill is based on the proficiency in encoding information, the execution of learning strategies such as organization and rehearsal, the flexibility of information retrieval, the ability to attend to a task, and overall recall ability (e.g., Chi, 1976; Cohen, Quinton, & Winder, 1985; Jablonski, 1974; Kail, 1990; Robinson & Kingsley, 1977).

Young children often fail to spontaneously use learning and memory strategies. However, they are more likely to use learning strategies if they know when and where they are appropriate. Children's increased knowledge about "knowing what, when, and how to know" (i.e., metamemory) leads to increased proficiency in learning strategies as the children grow older (Borkowski, Milstead, & Hale, 1988).

In addition to the increased use of mnemonic or learning strategies, children gain a more substantial "knowledge base" as they grow older (Chi, 1976). Associations are made among the information in the knowledge base, allowing for greater ease of access to the information. It is through a greater familiarity and number of associations that the child can consolidate ever-increasing amounts of information and thus become more proficient in learning and memory tasks. However, these tasks cannot be performed without attention (Anderson, 1990; Wellman, 1988).

Much of children's learning not only takes place in a structured setting in which the information to be learned is obvious (i.e., intentional learning situation) but also in situations where learning of non-intended facts occurs (i.e., incidental learning situation). This means that children learn merely because there is information within a particular situation that can be stored in memory, not because they are in a demand or intentional learning environment. However, Anderson (1990, p. 186) purports that the issue of learning is not necessarily one of intention but of how information is processed. Children who intend to learn are more likely to use strategies that are conducive to enhancing memory than children who, by coincidence, learn information in a non-demand or incidental learning situation.

Children use their metamemory to assess what actually occurred and did not occur in a given situation. Subsequently, they utilize strategies to remember only that information demanded by the situation rather than extraneous or irrelevant information that was not part of the situation and does not need to be remembered (Bisanz, Bisanz, & Kail, 1983, p. 143). However, sometimes this irrelevant information is remembered and is often the subject of research. This effect is assessed by interference effects. Two types of interference are generally studied--retroactive and proactive (Ellis & Hunt, 1983). Retroactive interference occurs when the retention of the original information decreases after learning additional information. Proactive interference occurs when retention of the additional information decreases due to learning the original information.

In reviewing the errors which may occur in acquisition, research has utilized two basic techniques--recognition and recall tests (Bugelski, 1979). As in the first memory studies by Ebbinghaus, memory performance is measured by the ability to recall the stimulus information in the same order as presented (i.e., serial recall or seriation). However, the free-recall method, designed by Bousfield (1953, cited in Bugelski), allows the subject to recall stimulus information in random order, thus placing the emphasis on simple availability of information rather than generating the information in some predefined order. Recognition is generally viewed as a more sensitive test of memory storage than recall since it often reveals more retention of information (Bugelski) and requires no generation of information but mere recognition of the information upon presentation.

A classic test of AV memory is the Auditory Verbal Learning Test (AVLT, Rey, 1964), a multi-trial, free-recall test of word-list learning. The AVLT is popular among clinicians because of its ease of administration, multiple measures of learning and memory, and apparent sensitivity to memory impairment (e.g., Bishop, Knights, & Stoddart, 1990; Forrester & Geffen, 1991; Geffen, Moar, O'Hanlon, Clark, & Geffen, 1990; Mitrushina, Satz, Chervinsky, & D'elia, 1991; Wiens, McMinn, & Crossen, 1988). For the most part, early writings about the AVLT focused on adult patients with neurological and psychiatric disorders. It has only been recently that more research has been completed on normal adult samples and some young children samples to establish a preliminary set of norms upon which clinical diagnoses can be based. Such norms have included indices for short-term verbal memory, verbal learning, post-interference recall, and recognition, as well as influential factors such as age and intelligence. However, little focus has been made on the errors which occur in AVLT performance.

Normative Acquisition in AV Memory

Children. The development of AV memory acquisition during childhood is assumed to be age-related, where greater age is related to greater cognitive control and capacity which, in turn, yields greater retention of information during multi-trial, free-recall tasks (Cole, Frankel, & Sharp, 1971). Curry, Logue, and Butler (1986), in measuring immediate recall in children (9-16 years), found that age was the greatest predictor of memory performance. Children 12 years and older had significantly greater recall ability than did children younger than 12 years. In contrast, they did not find that sex, ethnicity, or socioeconomic status covaried with memory performance.

Mohan and Dhaliwal (1988) found age to be most predictive of memory performance in older subjects. Regardless of which sex, 16- and 20-year-old subjects correctly recalled more words in immediate and delayed recall than younger subjects (12 years).

Friedrich (1974) is one of the few researchers who has studied differences in organizational strategies in children. He found that 7- and 10-year-old children recalled less information than 14- and 17-year-old children. Through manipulating the associative strength between words in a list, he also showed that 7-year-olds used optimal learning strategies (i.e., grouping of associated words together) less than older children or adolescents used them. These results seem to show that development of memory performance parallels cognitive development where the growth of reasoning and categorizing skills increases with age.

Wachs (1969) studied the relationship of intelligence to total free recall of words and found nonsignificant correlations between age and total recall scores and between intelligence and total recall scores; however, in a multi-trial, written-recall test of a 50-item word list, age x trial and intelligence x trial interactions were found. Specifically, older children had higher recall scores per trial, and children with high intellectual level had higher recall scores per trial than children with low intellectual level.

In studies similar to Wachs', Robinson and Kingsley (1977) and Prokopcakova (1984) both found that age and intelligence were major influential factors in word-list recall. Specifically, second and fourth graders of high intellectual ability recalled more words than their respective grade cohorts of average ability.

In response to their findings that both age and intelligence influence word-list recall, Robinson and Kingsley (1977) posited that differences in memory performance are probably indicative of proficiency in learning strategies. Since intelligence can be viewed as the ability to integrate knowledge in a discerning manner to a variety of situations (Borkowski, Milstead, & Hale, 1988), perhaps intelligence can then be merely a more inclusive definition of strategy usage which is an accepted predictor of memory performance in general memory theory.

Adults. Although many confounds arise when applying research findings for adults to child populations, the insight provided by the adult research cannot be overlooked. As with the studies on children, research with adults confirms the influence of intellectual level on AV memory acquisition (e.g., Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Query & Berger, 1980). Both Bleecker et al. and Query and Berger used the AVLT to assess AV memory acquisition in normal, healthy adult males and in adult male alcoholic, brain damaged, and ulcer victim in-patients. They found that for all subjects, the greater the intellectual ability, the greater the ability to learn a word list and recall it accurately.

Schear and Craft (1989) also examined the correlations among AV memory and intellectual level using the California Verbal Learning Test (CVLT). The CVLT is similar to the AVLT in that it attempts to assess the strategies and processes involved in learning and remembering word lists over repeated trials. Moderate to strong correlations were found between the CVLT scores and full scale IQ on the Wechsler Adult Intelligence Scale--Revised (r = .22 to .53). Schear and Craft suggest that other processes such as attention, vocabulary, and metamemory (or strategy proficiency) may also be involved in AV memory in order to account for the remaining amount of variance not accounted for by the correlations between memory performance and intelligence. It is possible, however, that memory and intellectual ability are more strongly correlated among a normal subject sample than among Schear and Craft's clinical sample.

In addition to intellectual level, studies with adults have investigated the influence of sex (Ardila & Rosselli, 1989; Bleecker et al., 1988; Kramer, Delis, & Daniel, 1988; Orsini et al., 1986; Orsini et al., 1982) and education (Ardila & Rosselli, 1989; Bleecker et al., 1988; Orsini et al., 1986; Query & Berger, 1980; Query & Megran, 1983) on AV memory performance. The effects of these variables are best summarized by Ardila and Rosselli (1989). They analyzed the effects of age (55-76+ years), educational level (0-5 years, 6-12 years, and more than 12 years of schooling), and sex on performance on a battery of neuropsychological tests. Included in the test battery was a multi-trial, word-list memory task. They found that adults with more education, regardless of sex, were capable of recalling more words in fewer trials. For 20-minute delayed recall, younger adults recalled more than older adults, and adults with more education recalled more than those with less education.

Errors in AV Memory

In recall memory it is quite common for subjects to recall words that were not formally presented to them (i.e., intrusion errors), and in recognition memory it is quite common for subjects to affirm that they heard a word previously during a task when they actually did not (i.e., false positives). These phenomena have been hypothesized to be related to semantic similarity or organizational generalization (Lee, Loring, Flanigin, Smith, & Meador, 1988; Underwood, 1982, p. 114-115). In other words, the more semantically similar an intruding or false positive word is to the actual words in a stimulus list (i.e., the more similar in meaning the word is), the more likely it is to appear in recall or recognition. For example, subjects may replace the word down with the word up or the word house with the word home in a recall or recognition task. In contrast, Drewnowski and Murdock (1980) found that subjects' memory errors were related more to acoustic similarity (36.2% of all errors) than to semantic similarity or generalization (9.5% of all errors). Acoustic similarity is manifested when both the correct and incorrect word share the same number of syllables, location of stress in the word, and the same phonetic sounds (e.g., confuse versus abuse and present versus prevent).

Shindler, Caplan, and Hier (1984) compared the memory performance of healthy adult subjects with the memory performance of adults with varying degrees of dementia (Alzheimer's, dementia other than Alzheimer's, and aphasia). They found that AV memory intrusions were not correlated with dementia severity per se.

Subjects with dementia produced significantly more intrusions than healthy subjects; however, subjects with lesser degrees of dementia did not significantly differ in the amount of intrusions from those with more severe dementia.

Shindler et al. (1984) propose two possible explanations for the appearance of intrusions. First, intrusions may be linked to defective memory via loss of acetylcholine-releasing neurons. However, they argue that this cannot fully explain the presence of intrusions. In their belief, it is more likely that intrusions merely appear when subjects are unable to retrieve information from long-term memory, substitute their responses with alternative (and thus incorrect) selections from short-term memory, and then fail to suppress this incorrect response. Thus, intrusions may be a result of an inability to use memory recall strategies appropriately.

Friedrich (1974) attempted to assess intrusion errors, as well as total memory, finding that intrusions appear to be a developmental phenomenon among children. He reported that 7-year-olds produce more intrusion errors in recall than adolescents (14 and 17 years). He suggested that, as reflected in intrusions, young children have difficulty retaining information because of their limited total memory capacity and use of associative strategies, such as organization and categorization, relative to adolescents. In comparing the findings of Friedrich (1974) with his sample of children and the findings of Shindler et al. (1984) with their sample of adults, one of the key issues in the appearance of intrusions is the use of learning strategies where greater proficiency in learning strategies leads to fewer intrusions in memory performance.

Just as age and intellectual ability influence total number of words recalled correctly, they both appear to influence intrusion errors as well. Robinson and Kingsley (1977) support this in their study of the general learning curve in repeated-trial, free recall of a 10-word list as a function of age and IQ. In testing normal second and fourth graders they found the absolute frequency of intrusion errors to be quite low. Second graders averaged only .93 (i.e., less than one) intrusions and fourth graders only .07 intrusions during the learning session. However, significant differences in the number of intrusions occurred between age groups and IQ groups. As age and intellectual ability increased, subjects' intrusion errors were found to decrease.

In clinical assessment of children's and adults' intellectual and psychoeducational performance, profile analyses are often compiled (Sattler, 1990). These analyses target areas of strength and weakness and allow for "the development of hypotheses that can contribute to an understanding" of the client (p. 166). Common methods used for profile analysis include an imbalance hypothesis which reflects disparate ability in two or more areas. Specifically, as two abilities become more disparate, the likelihood of learning problems in the depressed performance area becomes greater. Although intellectual imbalance has never been formally studied in relation to AV memory performance, the present study asserts that this common clinical tool may be more useful than mere overall ability in assessing and explaining the occurrence of intrusion errors and false positives.

AVLT Performance

In recent years, the literature has reflected a push by clinicians to establish updated and inclusive norms for the AVLT using healthy adult and child samples. Such studies have broken down AVLT performance by trial, age, and intelligence.

Several studies using adult samples have contributed to a basic understanding of the process of memory over trials in AVLT performance and how it is influenced by age and intelligence (Geffen et al., 1990; Mitrushina et al., 1991; Selnes et al., 1991; Wiens et al., 1988). Geffen et al. (1990) report the most comprehensive findings that best summarize these studies. In studying the performance of 153 healthy Australian adults aged 16 to 86 years, they found that recall significantly increased on each subsequent learning trial regardless of age and IQ. Elderly adults (70+ years) recalled less overall than young adults (16-29 years), just as males recalled less overall than females. IQ was significantly related to first-trial learning recall, post-interference recall, and delayed recall, where those with greater IQ had greater recall. Even more specifically, Wiens et al. (1988) found this significance to hold true when IQ was broken down into verbal (VIQ) and performance (PIQ) measures. In comparing delayed recall and delayed recognition, Geffen et al. (1990) additionally found recognition scores to be significantly greater than recall, indicating greater efficiency in recognition memory.

Using stepwise regression analysis, Geffen et al. (1990) determined a model of relative contribution, where age accounted for the greatest proportion of variance on all recall trials, followed by gender, IQ, and level of education respectively. In addition, they found both significant proactive interference effects and retroactive interference effects. However, no significant differences in overall number of intrusions were found between age or IQ groups.

The AVLT performance of children is quite similar to that of adults (Bishop, Knights, & Stoddart, 1990; Forrester & Geffen, 1991). In studying 7- to 15-year-old Australian children, Forrester and Geffen (1991) found recall to increase significantly over learning trials as in the Geffen et al. (1990) study with adults. However, in contrast to the Geffen et al. finding that overall performance decreased with age in adults, Forrester and Geffen found children's overall recall to increase with age, and no significant sex differences were found. They also found a retroactive interference effect like in the adults but no proactive interference effect. In comparing delayed recall with delayed recognition, Forrester and Geffen found children's recognition scores to be significantly greater than recall scores, supporting the Geffen et al. finding that recognition memory is more efficient and an easier task than recall. Forrester and Geffen additionally found a trial x age interaction indicating a maturational effect in recall efficiency, where the difference between recall and recognition scores decreased as the children's age increased.

It appears then that AVLT performance remains relatively stable with age except for overall memory. Adults' performance appears to decline overall among the elderly, yet children's performance appears to reflect a developmental effect of increased total recall and recognition with increased age. Similarly, children appear to show more efficient memory performance with greater intellectual level as do adults.

Summary of Literature and Purpose of the Present Study

The study of AV memory is of interest to clinicians due to its application to every day life. In a world where information is obtained audibly in intentional and incidental settings, the process in which children build their knowledge base rests on their ability to adequately encode, store, and retrieve a vast amount of information. Continued assessment of this process provides clinicians with data to establish norms which can then be used to target children with learning problems and to develop remedial programs.

The AVLT (Rey, 1964) is popular among clinicians because of its ease of administration, multiple measures of learning and memory, and apparent sensitivity to memory impairment (e.g., Bishop et al., 1990; Forrester & Geffen, 1991; Geffen et al., 1990; Mitrushina et al., 1991; Wiens et al., 1988). Although popular, researchers have only recently started to establish inclusive norms for the AVLT using healthy adult and child samples. Toward this end, the findings of Geffen et al. (1990) have contributed to a more basic understanding of AV memory acquisition. Specifically, AVLT recall in adults aged 16 to 86 years significantly increased on each subsequent learning trial. Using stepwise regression analysis, Geffen et al. developed a model of relative contribution, where age accounted for the greatest proportion of variance on all recall trials, followed by gender, IQ, and level of education respectively.

Forrester and Geffen (1991) found AVLT performance of 7- to 15-year-old children to be quite similar to that of adults, where recall increased significantly over trials. In addition, children's overall recall increased as age increased.

An area not addressed in the more recent push to establish AVLT norms is errors in memory (i.e., intrusions in recall and false positives in recognition). However, in researching general AV memory, Shindler et al. (1984) proposed that intrusions in adult AV memory performance may be a result of an inability to use memory recall strategies appropriately. Similarly, Friedrich (1974) suggested that intrusions in children's AV memory performance are related to learning strategy proficiency as reflected by an increase in age. In other words, as children's age increases, or as learning strategy proficiency increases, production of intrusions decreases. Robinson and Kingsley (1977) further reported that age and intellectual ability are negatively related to intrusion errors in AV memory, where as age and intellectual ability increase, the frequency of intrusions decreases. The literature clearly establishes intrusions as a phenomena found in AV memory performance. However, in the quest to develop norms for AVLT performance, studies have merely shown that errors exist. Researchers need to assess what these errors mean in relation to memory performance on the AVLT, providing a more comprehensive analysis of what the AVLT actually measures.

The present study investigated the acquisition process of AV memory as reflected in scores received on the AVLT and examined intrusion errors and false positives among children aged 7 to 11 years in order to gain a deeper understanding of AV memory and aid in the development of norms. Although previous studies have looked at children within a greater age range (e.g., 7 to 15 years in Forrester & Geffen (1991)), the present study believes that the greatest developmental change occurs during Piaget's concrete operational period. From a clinical viewpoint, children under 7 years of age do not yet perform at an academic level indicative of their actual intellectual ability, and it is often not until around age 7 that depressed academic performance becomes a concern. After age 12, it is often too late to adequately resolve any learning problems, thus age 7 to 12 years is a prime time for clinical intervention.

In addition to examining AV memory acquisition, intrusion errors, and false positives, the present study examined the level of influence from age, intellectual ability, and attention on AV memory performance. The findings from this investigation should be helpful for clinicians in assessing and diagnosing children with depressed academic performance.

Primary hypotheses. The present study had three primary foci. First, it looked at AVLT memory performance developmentally by evaluating the influence of age and intellectual ability. As the literature suggests (Friedrich, 1974; Prokopcakova, 1984; Robinson & Kingsley, 1977; Wachs, 1969), memory acquisition and the production of intrusions and false positives are normal developmental phenomena among children; thus, it was expected that as age increased, total memory would increase and frequency of memory errors would decrease. As general intellectual ability increased, it was expected that there would be greater total memory and fewer memory errors.

Since both age and intelligence are reported in the literature to influence memory performance, this study assumed that perhaps neither chronological age nor intelligence should be used as singular predictors. Mental age (MA), however, accounts for both a person's chronological age and intellectual ability by yielding an age-equivalent score as a measure of cognitive functioning (Sattler, 1990). Thus, it was expected that MA would provide a more precise picture of how these variables covary with AV memory performance. More specifically, since intellectual ability is assumed to be indicative of metamemory (i.e., greater intelligence reflects more proficient strategy usage--Borkowski et al., 1988), it was hypothesized that MA would be more predictive of memory performance than mere chronological age or intelligence.

Second, the present study defined the relationship of AV memory acquisition and the production of memory errors (i.e., intrusions in recall and false positives in recognition). Previous studies on the AVLT acknowledged the presence of memory errors (e.g., Geffen et al., 1990) but neglected to investigate how these errors covary with overall performance. This study assumed that people who have good recall ability also have good control over memory errors (i.e., have fewer intrusions and false positives). Therefore, it was hypothesized that as total memory increased, memory errors would decrease. This relationship was expected to be observed in children's performance at the beginning and end of a learning task. In addition, children who showed learning gain, or were able to "catch up" in a task, were also expected to show good control over memory errors. More specifically, if they recalled most words at the end of a learning task even though they recalled only a few words at the beginning of a task, they were expected to produce few intrusions and false positives.

Third, the present study was designed to gain a more precise understanding of the phenomena of acquisition, interference, intrusion errors, and false positives in children's AV memory by evaluating how these aspects of memory covary with each other. Based on general memory theory, the AVLT was assumed to reflect a single process over trials in memory performance and in errors during memory performance. Specifically, those children who recalled more words at the beginning of a learning session were expected also to recall more words at the end of a session, and those who had few errors at the beginning were expected also to have few errors at the end.

<u>Secondary hypotheses.</u> The present study addressed four areas of secondary interest. First, classic measures of ability and dysfunction were used to investigate more fully how intellectual ability covaries with memory performance. An imbalance hypothesis was offered asserting that children's intellectual ability consists of two skill sets--perceptual and verbal--which need to be of relatively equal strength. Both skills are necessary for storage (i.e., memory) of information, but if one skill is better than the other, an imbalance occurs, possibly causing learning problems. Thus, as children's perceptual ability and verbal ability become more disparate (or as the absolute measure of the difference between abilities increases), it was expected that children would exhibit more problems with acquisition, recall and recognize fewer

words overall, and produce more intrusions and false positives overall.

Secondly, this study addressed the influence of attention on AV memory performance. Although general memory theory suggests that an individual must be able to attend to a learning situation in order to properly encode, store, and thus retrieve information (Anderson, 1990; Wellman, 1988), previous studies on the AVLT have not controlled for attentional ability. Intellectual ability and age are not sufficient to predict memory performance. Limited attentional ability may hinder a child from completing a task thus producing depressed performance scores and an inaccurate measure of intellectual level. It was hypothesized that as attentional ability increased (as reflected in behavior), total memory would increase and intrusions and false positives would decrease.

Thirdly, MA, age, intellectual imbalance, and attention were hypothesized to account for significant levels of variance in AV memory performance. In an effort to build a model for explaining the process of AV memory, similar to work done by Geffen et al. (1990)[1], a stepwise regression analysis was expected to reveal each variable's significant relative contribution to memory performance.

Lastly, an effort was made to reliably generalize the findings of this study to children in the general public rather than to just those seen in a clinical setting. No significant difference in memory performance was expected between clinical and non-clinical groups, assuming that they were of equal age and ability.

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[1]Refer to p. 11 for a discussion of this study.

METHOD

Subjects

Out-patient sample. The main sample included clients from a university out-patient, child guidance center ranging in age from 7 to 11 years ($N = 50$). Archival data from clients' extensive psychoeducational and neuropsychological batteries were utilized. These batteries included scores on the AVLT, the Wechsler Intelligence Scale for Children--Revised (WISC-R, Wechsler, 1974), and the Conners Parent Rating Scale, a behavioral measure of learning and conduct problems (Conners, 1985). Subjects included in the sample had visited the clinic to be tested and treated primarily for family conflicts, school-related problems, or depressed academic performance. Any subjects with suspected or diagnosed brain damage or depressed intelligence (full scale IQ $\leq$ 75) were excluded from the sample.

Subjects ranged from middle-lower SES to lower-upper SES and represented a variety of ethnic groups. The majority of subjects were male (male $n = 39$; female $n = 11$), right-handed (right $n = 42$; left $n = 8$), and of average intelligence (full scale IQ range = 72-115; $M = 93$; $SD = 11.42$). Although the age range of 7 to 11 years (or 79 to 138 months) may be considered narrow by some, the mental age (MA) range of the main sample was greater (5 to 13 years or 62 to 158 months) than that of mere chronological age thus expanding the sample to reflect a wider range of ability.

Comparison sample. Because the main sample was composed of out-patients, archival data from a second sample of children was gathered for secondary comparative analysis to see how the occurrence of memory errors in a clinical sample is similar to the findings in a nonclinical sample. Subjects (N = 25; male n = 12; female n = 13) ranged in age from 7 to 11 years and were selected from a university children's center and from families of undergraduates, representing mostly white, middle class homes.

Subjects had completed a simplified subset of the test battery used by the out-patient sample as part of a study done by undergraduates. Included in this test battery were the AVLT, the vocabulary subtest of the WISC-R as a measure of intelligence (median loading on g = .80, Sattler, 1990), and the Conners Parent Rating Scale. Subjects who showed high levels of learning or conduct problems as measured by the Conners Parent Rating Scale (SD = ±1.5) were removed from the sample, so the remaining subjects were considered normal relative to the out-patient sample.

Materials and Procedure

Auditory Verbal Learning Test. Scores from the AVLT (Rey, 1964, see Appendix A) were used as measures of AV memory performance. Although no reliability and validity data is published on this popular clinical tool, this test is used and cited in most assessment books (see Lezak, 1983) as a competent measure of AV memory performance. The present study in essence assessed the validity of the AVLT by analyzing its ability to evaluate general memory performance.

The AVLT consists of a list of 15 concrete nouns (list A) which are read to the subject at a rate of one word per second for five consecutive trials, where each reading is followed by a free-recall period (Lezak, 1983). During the free-recall period, the subject is allowed to recall as many words as possible until 10 seconds have lapsed from the last new and correctly recalled word (a variation on the original technique). This is to assure that recall is actually complete.

Upon completion of the fifth trial, a 15-word interference list (list B) is presented in the same way as the first list (A) and is also followed by a free-recall period. This interference trial (Trial 6) provides a measure of proactive interference recall, where the previously learned words are assumed to hinder learning of the new B list (Lezak, 1983). A seventh trial consists of non-prompted free recall where the subject is asked to recall as many of the words as possible from list A without having the list reread or presented. This post-interference trial provides a measure of retroactive interference recall, where the newly learned words (or list B) are assumed to hinder recall of the previously learned words from list A (Lezak).

A recognition trial (developed by Lezak, 1983, see Appendix B) follows where the subject must identify words from list A when read a list of 50 words containing all words from both lists A and B, as well as words semantically or phonemically similar to those in lists A and B. Finally, after a 30-minute delay, during which other testing occurs, the subject is again asked to freely recall as many of the words as possible from the original list (A) without having the list reread or presented (as in the post-interference trial).

On each trial, several scores are noted: number of words recalled correctly, number of intrusion errors or words recalled that were not part of the list, and, on the recognition trial, number of words correctly recognized and number of false positives or words incorrectly recognized as being part of the original list.

Wechsler Intelligence Scale for Children--Revised. Scores from the WISC-R (Wechsler, 1974) were used as measures of intellectual ability. The full scale IQ (FSIQ) provides a measure for overall intellectual functional level. The verbal IQ (VIQ) provides an index of general verbal skills, including measures of competence on the information, similarities, arithmetic, vocabulary, comprehension, and digit span subtests. These scores reveal that the greater the VIQ, the greater the subject's mastery of verbal processes. The performance IQ (PIQ) provides an index of general perceptual skills, including measures of competence on the picture completion, picture arrangement, block design, object assembly, coding, and mazes subtests. These scores reveal that the greater the PIQ, the greater the subject's mastery of perceptual skills (Sattler, 1990).

Based on 11 age groups (6-16 years), reliability coefficients are .96 for FSIQ, .94 for VIQ, and .90 for PIQ. Concurrent validity correlations with various other intelligence tests range from the upper .30s to the low .80s (Sattler, 1990).

Since the literature suggests that both age and intelligence influence AV memory performance (Prokopcakova, 1984; Robinson & Kingsley, 1977; Wachs, 1969), the present study defined general cognitive ability by a mental age (MA) conversion of the WISC-R standard scores even though no other studies on the AVLT have included MA in their analyses. This provided a measure of cognitive functioning by yielding an age-equivalent score since MA reflects a more absolute index of a child's cognitive performance level, regardless of age, than does IQ which is based purely on ability (Sattler, 1990).

Specific measures of mental age were estimated using MA conversions of the FSIQ, VIQ, and PIQ from the WISC-R. In addition, MA conversions were made of Kaufman's (1975) three factor analytically derived indices which are now incorporated in the WISC-III. Kaufman's indices include the Verbal Comprehension Deviation Quotient (VCDQ), Perceptual-Organizational Deviation Quotient (PODQ), and Freedom from Distractibility Deviation Quotient (FDDQ).

In his complete factor analysis of the WISC-R, Kaufman found that VCDQ is a more refined measure of verbal ability and the mental process of comprehension than is VIQ; it includes the information, similarities, vocabulary, and comprehension subtests of the WISC-R. He concluded PODQ is a more refined measure of perceptual ability and the mental process of organization than is PIQ; it includes the picture completion, picture arrangement, block design, and object assembly subtests. He asserted FDDQ measures the ability to remain attentive; short-term memory; sequencing; encoding; and strategies such as rehearsal, use of symbolic material, and self-monitoring. It includes the arithmetic, digit span, and coding subtests (Sattler, 1990).

In addition to calculating MA conversions, Selz and Reitan's measure of intratest scatter (1979) was noted for each subject. The scatter index analyzes the subject's pattern of scaled scores on the WISC-R: [(scaled $score_{high}$ - scaled $score_{low}$) / scaled $score_{M}$]. It provides a base-free statistic of the subject's range of scores taking out the actual, or mean, level of performance and targeting areas of strength and weakness. For example, a large scatter index ($\underline{s} > 0.6$) indicates possible areas of weakness in ability as shown by the lowest scaled scores.

Conners Parent Rating Scale. Scores from the Conners Parent Rating Scale (Conners, 1985) were used as measures of how parents perceived their child's behavior. Specifically, the Conners' questionnaire lists seven categories of behavioral situations. Parents then rate their child's behavior in each situation on a four-point scale (0 = not at all; 1 = just a little; 2 = pretty much; and 3 = very much). Six behavioral indices are calculated by the examiner, yet only the indices of learning problems, impulsive/hyperactive, and hyperactivity were used in analysis. These three indices were assumed to reflect the child's attentional ability.

RESULTS

Primary Analyses

Correlational and t-test analyses were performed to examine the three primary foci of this study--(a) the influence of age and intellectual ability on AV memory performance development, (b) the relationship between memory acquisition and memory errors, and (c) a comprehensive analysis of subjects' AV memory performance over trials. An alpha level of .05 was used for all primary statistical analyses.

Eight memory performance measures were used in all analyses (Geffen et al., 1990; Wiens et al., 1988). These performance measures were taken from AVLT scores of total number of words correctly recalled or recognized and total number of intrusions and false positives for each trial and are defined as follows: first-trial learning as scores on Trial 1; end-trial learning as the sum of scores on Trials 4 and 5; total memory as the sum of scores on Trials 1 through 5; learning gain as the difference between scores on Trials 1 and 5 using the equation (Trial 5 - Trial 1); proactive interference memory as the difference between scores on Trials 1 and 6 (the interference trial) using the equation (Trial 1 - Trial 6); retroactive interference memory as the difference between scores on Trial 5 and Trial 7 (the post-interference trial) using the equation (Trial 5 - Trial 7); recognition memory as scores on the recognition trial; and delayed-recall memory as scores on the 30-minute delay trial.

Influence of age and intellectual ability. Subjects were ranked according to increased age, intellectual ability, and general memory performance to test the hypothesis that older children and children with a higher intellectual level have greater total memory scores and produce fewer memory errors than younger children and children with a low intellectual level. Spearman rank correlations were computed for the memory performance measures with age and IQ. These results are presented in Table 1 and show that four of the eight memory performance measures significantly correlated with age and five significantly correlated with FSIQ.

Spearman correlations were also made with the performance measures and the mental age (MA) conversion of FSIQ. Five of the eight memory performance measures significantly correlated with MA as with FSIQ (Table 1).

Since no significant correlations were found between errors in memory performance and age, FSIQ, and MA, MA conversions of verbal ability (VIQ and VCDQ) and perceptual ability (PIQ and PODQ) were included in analysis. Only perceptual ability was significantly correlated with errors in memory performance, where the MA conversion of PIQ had a greater correlation than mere PIQ. More specifically, as perceptual ability increased, first-trial intrusions decreased [r (36) = -.30, p = .038], revealing that children who were adept at perceptually oriented tasks such as arranging pictures or completing mazes were less likely to recall words that were not formally presented to them at the beginning of a learning task (i.e., less likely to produce intrusion errors).

Although age, FSIQ, and MA all significantly correlated with at least four memory performance measures, subjects were then categorized into age groups, IQ groups, and MA groups in order to assess in more detail how memory performance

Table 1

Correlations Between Correct Memory Performance Scores and Age and Intellectual Ability

	Age	FSIQ	MA
First-trial Learning	.42**	.51***	.57***
End-trial Learning	.41**	.43**	.52***
Total Memory	.43**	.42**	.53***
Learning Gain	.28*	.21	.30*
Proactive Interference	.17	-.03	.11
Retroactive Interference	-.07	-.23	-.22
Recognition Memory	-.15	.50*	.25
Delayed-recall Memory	.37	.39*	.50**

Note. FSIQ = full scale IQ; MA = mental age. All memory performance measures have $n = 36$ except recognition memory ($n = 17$) and delayed-recall memory ($n = 19$) due to the limited availability of these items in the archival data.

*$p < .05$. **$p < .01$. ***$p < .001$.

changes with increased age and intellectual ability. First, age was transformed from a continuous variable measured in months to a grouping variable measured in years (e.g., 7-, 8-, 9-, 10-, and 11-year-olds). One-way analyses of variance (ANOVAs) were performed for each memory performance measure by age group, but no significant differences between age groups were found. In other words, AV memory scores received by 7- to 11-year-old children were relatively the same. Realizing that the overall age range in the sample was limited, age was then categorized into only two groups (7- to 9-year-olds and 10- to 11-year-olds). Results showed that only end-trial learning was significantly different by age group [t (34) = -2.09, p = .045] such that 10- to 11-year-olds scored higher than 7- to 9-year-olds scored. This means that after trying to learn a list of words over a period of time, 10- to 11-year-olds recalled more of the words than 7-to 9-year-olds recalled.

Second, IQ was categorized into two groups: (a) subjects whose FSIQ was more than one standard deviation below normal (i.e., FSIQ = 70-84), and (b) subjects whose FSIQ was within one standard deviation above and below normal (i.e., FSIQ = 85-115). *T*-tests were performed for each memory performance measure by IQ group. Only first-trial learning [t (34) = -2.82, p = .008] and recognition memory [t (15) = -2.56, p = .022] were significantly different by IQ group, where children with higher IQ scores had higher first-trial learning and recognition scores. In other words, when compared to children with a below-normal IQ, children within the normal IQ range recalled more words on their first attempt at learning a word list and also recognized more words correctly.

Third, MA (based on FSIQ) was categorized into six groups (e.g., 5-6, 7, 8, 9, 10, and 11-13 years). One-way ANOVAs were performed for each memory performance measure by MA group. Children in the higher MA group (11- to 13-year-olds) scored higher than children in lower MA groups (5- to 8-year-olds) on first-trial learning [F (5, 30) = 4.74, p = .003], end-trial learning [F (5, 30) = 3.73, p = .009], total memory [F (5, 30) = 3.85, p = .008], recognition memory [F (5, 11) = 7.03, p = .003], and delayed-recall memory [F (5, 13) = 2.94, p = .054]. This showed that, regardless of age, AV memory performance increased as ability increased. More precisely, when chronological age is disregarded, children's fundamental level of intellectual ability (i.e., MA) was directly related to many facets of AV memory performance. Compared to children with a low MA, children with a high MA recalled more words on their first attempt at learning a word list, recalled more words at the end of a learning task, recalled more words overall during a learning task, later recognized more words that they had initially learned, and, 30 minutes later, still recalled more words from the initial learning task.

To summarize, results showed that age, FSIQ, and MA all influenced AV memory performance; however, differences in children's MA accounted for a greater number of significant differences in memory performance. Compared to those with a low MA, children with a high MA (a) recalled more words overall; (b) recalled more words at the beginning, at the end, and 30 minutes after completing a learning task; and (c) recognized more words from the learning task.

Relationship of acquisition and errors. A Pearson product-moment correlation matrix was computed to compare correct scores in memory performance with intrusions and false positives.[2] Results showed that first-trial learning had no significant relationship with any memory error measures. However, children who correctly recalled more words during end-trial learning produced significantly fewer false positives during recognition [$\underline{r}$ (17) = -.44, $\underline{p}$ = .040]. In other words, children who recalled more words after having spent a period of time practicing a learning task were less likely to affirm that they heard a word previously during the learning task when they actually did not hear the word (i.e., less likely to produce false positives). Results also showed that children who achieved greater learning gain over the five trials produced fewer first-trial intrusions [$\underline{r}$ (36) = -.31, $\underline{p}$ = .035] as well as fewer false positives during recognition [$\underline{r}$ (17) = -.74, $\underline{p}$ < .001]. This means that some children were able to "catch up" in their memory performance. Even though they recalled only a few words on their first attempt at learning a word list, they increased their recall to where they recalled most words at the end of the learning task (i.e., showed learning gain). These children who "caught up" had two significant features of their memory performance errors. First, compared to their cohorts, they were less likely to recall words that were not formally presented to them at the beginning of a learning task (i.e., produce intrusions). Second, they were less likely to incorrectly recognize a word as having been presented to them previously during a learning task

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[2]This correlation matrix has been omitted from presentation due to its extensive size. For additional information on this data, correspondence should be addressed to the author at her residence: Jane L. Mathews, 5268 Yosemite Drive, San Bernardino, California 92407.

(i.e., produce false positives).

Several significant relationships were found for total correct memory (Figures 1, 2, and 3). More specifically, children who had greater total memory (or correctly recalled more words overall) produced significantly fewer first-trial intrusions [$\underline{r}$ (36) = -.28, $\underline{p}$ = .046] (Figure 1), end-trial intrusions [$\underline{r}$ (36) = -.31, $\underline{p}$ = .032] (Figure 2), and total intrusions [$\underline{r}$ (36) = -.35, $\underline{p}$ = .018] (Figure 3). In other words, compared to other children, those who recalled more words overall during a learning task were less likely to recall words that were not formally presented to them (a) at the beginning of a learning task, (b) at the end of a learning task, and (c) overall during a learning task.

Several significant relationships were also found for delayed-recall intrusions. Children who produced many intrusions during delayed recall correctly recalled fewer words during delayed recall [$\underline{r}$ (19) = -.44, $\underline{p}$ = .029] and exhibited greater proactive [$\underline{r}$ (19) = .49, $\underline{p}$ = .017] and retroactive interference [$\underline{r}$ (19) = .44, $\underline{p}$ = .030]. This means that children who recalled words that were not formally presented to them 30 minutes earlier in a learning task (i.e., produced intrusions) also had difficulty recalling words that were formally presented 30 minutes earlier. In addition, they exhibited problems in two other areas of memory performance that their cohorts did not exhibit. First, they had difficulty with proactive interference (i.e., they were unable to recall words from a secondary word list after having spent time learning a previous list). Second, they had difficulty with retroactive interference (i.e., they were unable to recall words from their initial learning task after being interrupted

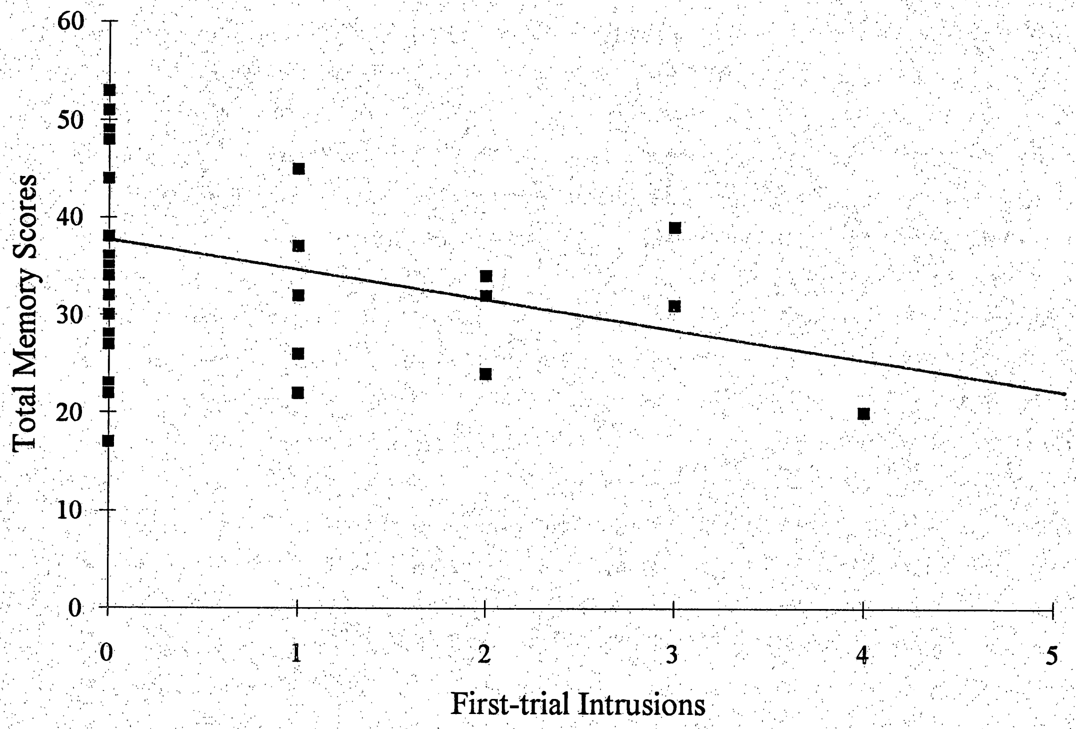
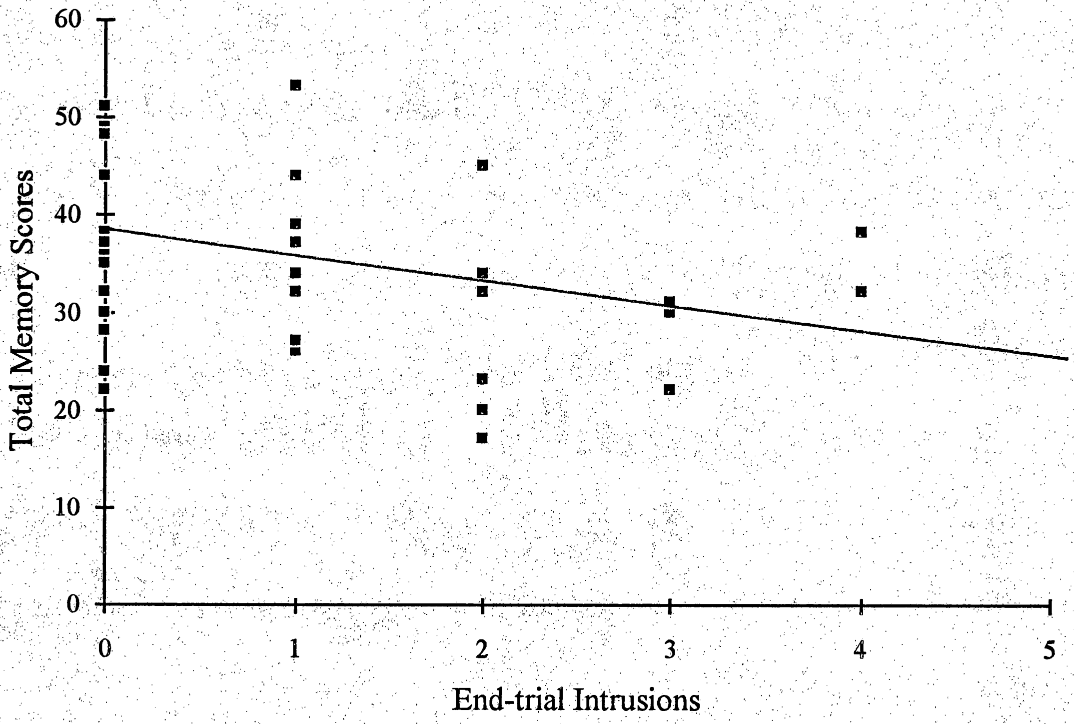


Figure 1. Relationship of total memory scores with first-trial intrusions ($\underline{n}$ = 36). The distribution reflects that as more words were recalled overall during a learning task, fewer first-trial intrusions were produced.



<u>Figure 2.</u> Relationship of total memory scores with end-trial intrusions ($\underline{n}$ = 36). The distribution reflects that as more words were recalled overall during a learning task, fewer end-trial intrusions were produced.

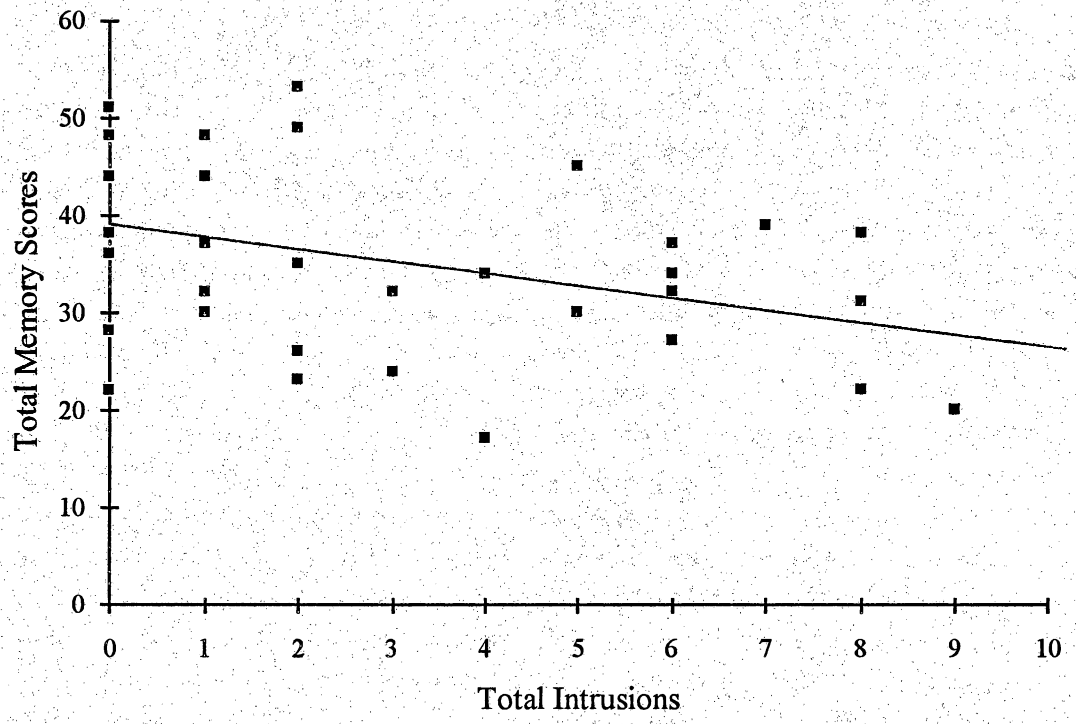


Figure 3. Relationship of total memory scores with total intrusions (n = 36). The distribution reflects that as more words were recalled overall during a learning task, fewer total intrusions were produced overall.

with the presentation of a secondary word list).

To summarize the relationship of AV memory acquisition and errors, results showed three key areas of performance on which to focus: (a) the ability to "catch up," (b) overall recall during a learning task, and (c) memory errors occurring 30 minutes after a learning task. First, those children who were able to "catch up" in a learning task (i.e., recalled only a few words at the beginning but most words by the end) produced few memory errors in both recall and recognition. Second, those children who recalled more words overall during a learning task produced fewer memory errors during the learning task. Third, those children who produced more memory errors 30 minutes after a learning task recalled fewer words 30 minutes later and had more proactive and retroactive interference.

<u>AV memory performance over trials.</u> Correlational analysis was performed to assess memory acquisition over repeated trials, the influence of interference on memory performance, the difference between recall and recognition memory, and the presence of intrusion errors and false positives. Separate Pearson product-moment correlation matrices were computed for correct memory performance (Table 2) and errors in memory performance (Table 3).

As shown in Table 2, first-trial learning is indicative of end-trial learning, where children who correctly recalled more words at the beginning of a learning task also correctly recalled more words at the end of a task. Although no significant correlations were found with retroactive interference, proactive interference significantly correlated with recognition, where as proactive interference decreased,

Table 2

Intercorrelations Among Scores from the Auditory Verbal Learning Test (Correct Memory Scores Only)

	2	3	4	5	6	7	8
1. First-trial Learning	.57***	.72***	-.02	.34*	-.12	.19	.21
2. End-trial Learning	---	.95***	.76***	.10	-.22	.23	.80***
3. Total Memory		---	.61***	.18	-.23	.21	.74***
4. Learning Gain			---	-.12	-.10	.09	.73***
5. Proactive Interference				---	-.09	-.47*	-.04
6. Retroactive Interference					---	.01	-.31
7. Recognition Memory						---	.48*
8. Delayed-recall Memory							---

Note. All memory performance measures have $n = 36$ except recognition memory ($n = 17$) and delayed-recall memory ($n = 19$) due to the limited availability of these items in the archival data.

$^{*}p < .05$. $^{***}p < .001$.

recognition increased. More specifically, compared to their cohorts, children who were able to recall words from a secondary word list after having spent time learning a previous list (i.e., had no proactive interference) were also able to correctly recognize words from a previous learning task. Table 2 also reveals that those children who correctly recalled words that had been presented to them 30 minutes earlier (i.e., showed greater retention) performed well in four additional areas. First, they recalled more words than their cohorts at the end of a learning task. Second, they recalled more words overall during a learning task. Third, even though they may have recalled only a few words on their first attempt at learning a word list, they increased their recall to where they recalled most words at the end of a learning task (i.e., showed learning gain or "caught up"). Fourth, compared to their cohorts, they correctly recognized more words from a previous learning task.

Table 3 shows the correlations of intrusions and false positives. Recognition false positives were not significantly correlated with intrusions in recall. However, intrusions that occurred during the learning trials (i.e., during acquisition) were indicative of intrusions in later memory performance. More specifically, children who produced more intrusions during their first trial of a learning task (i.e., recalled words that had not actually been presented to them) also produced more intrusions at the end of the learning task and 30 minutes after completing the learning task. Similarly, those who produced more intrusions either at the end of a learning task or overall during a learning task produced more intrusions 30 minutes after completing the learning task.

Table 3

Intercorrelations Among Scores from the Auditory Verbal Learning Test (Error Scores Only)

	2	3	4	5	6	7	8
1. First-trial Learning	.32*	.64***	-.73***	.47**	-.00	-.03	.52*
2. End-trial Learning	---	.78***	.33*	.11	.09	.23	.72***
3. Total Memory		---	-.17	.11	.03	.14	.62**
4. Learning Gain			---	-.29*	.23	.22	-.17
5. Proactive Interference				---	.12	-.36	.17
6. Retroactive Interference					---	.36	-..25
7. Recognition Memory						---	.09
8. Delayed-recall Memory							---

Note. All memory performance measures have $n = 36$ except recognition memory ($n = 17$) and delayed-recall memory ($n = 19$) due to the limited availability of these items in the archival data.

$*p < .05$. $**p < .01$. $***p < .001$.

Although additional significant correlations are noted in Tables 2 and 3, these correlations are confounded by the nature of the relationship compared. For example, first-trial learning is indicative of total memory (Table 2), and first-trial intrusions are indicative of total intrusions (Table 3). However, these correlational comparisons are confounded because scores from the first trial are reflected in each measure thus comparing scores from Trial 1 with scores from Trial 1. Although such comparisons of overlapping information are frequently done, this study did not include these comparisons because of the possible confusion posed for conceptual interpretation of AV memory performance over time.

To summarize AV memory performance over trials, results showed two areas on which to focus: (a) recall 30 minutes after a learning task, and (b) the relationship between errors made during and after a learning task. First, those children who recalled more words 30 minutes after a learning task also recalled more words overall and at the end of the task, "caught up" during the task, and recognized more words from the task. Second, those who produced more memory errors at the beginning of a learning task also produced more errors overall, at the end of the task, and 30 minutes after the task.

Secondary Analyses

The present study examined four areas of secondary interest: (a) the influence of intellectual imbalance on AV memory performance, (b) the influence of attention on AV memory performance, (c) the building of regression models to explain the process of AV memory performance over trials, and (d) the generalizability of findings from a clinical sample to a non-clinical sample. An alpha level of .05 was used for all secondary statistical analyses.

Influence of intellectual imbalance. Children's intellectual ability consists of two skill sets--perceptual and verbal--which need to be of relatively equal strength. Intellectual imbalance occurs as perceptual ability and verbal ability become more disparate, or as the absolute measure of the difference between abilities increases.[3] Such a measure of learning disability and interskill variability is often used in profile analyses by clinicians (Sattler, 1990).

To test the hypothesis that children with greater intellectual imbalance recall fewer words and produce more intrusions and false positives overall, intellectual imbalance was defined in two main ways--the scatter index (Selz & Reitan, 1979) and indices from the WISC-R. First, Selz and Reitan's measure of intratest scatter was computed for each subject.[4] Scatter refers to the subject's pattern of scaled scores on the WISC-R, targeting areas of strength and weakness. When Pearson product-moment correlations were computed for scatter with the AV memory performance measures, only one significant relationship resulted--recognition memory with scatter [r (16) = -.51, p = .02]. This shows that children whose performance varies greatly on WISC-R subtests (i.e., they have scaled scores that are both very low and very high) recognize fewer words from a previously learned list.

Second, intellectual imbalance was defined for the purposes of this study as

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[3]For further discussion of intellectual imbalance, refer to p. 17.

[4]For further discussion of scatter, refer to its description on p. 23.

differences and ratios between verbal and performance (or perceptual) indices from the WISC-R (see below). Each of these new variables reflected both directional and absolute measures of intellectual imbalance in order to explore which aspect of imbalance was most influential on memory performance, (a) perceptual ability being disproportionately greater than verbal ability, (b) verbal ability being disproportionately greater than perceptual ability, or (c) the mere presence of a difference existing between verbal and perceptual ability.

The following variables were included in analysis: (VIQ - PIQ) as a measure of disparity in verbal and perceptual ability; (VCDQ - PODQ) as a more specific measure of disparity using the Kaufman factor analytically derived indices (1975); [(VIQ - PIQ)/FSIQ] as an absolute measure of verbal and perceptual disparity as compared to general ability; and [(VCDQ - PODQ)/FSIQ] as a more specific and absolute measure of disparity as compared to general ability using the Kaufman factor analytically derived indices. The corresponding MA conversions of these four equations were also examined in order to assess the influence of intellectual imbalance disregarding age. To determine if mere imbalance or the direction of the imbalance was the influencing factor in AV memory performance, the absolute values of the eight aforementioned equations (for a total of 16 intellectual imbalance measures) were analyzed. A Pearson product-moment correlation matrix was computed for these intellectual imbalance measures by the memory performance measures.[5]

In assessing the absolute value of intellectual imbalance with the direction of influence ignored, only one significant correlation was found. As the absolute value of the difference between MA conversions of VIQ and PIQ increased, recall on first-trial learning increased [r (36) = .29, p = .043]. More specifically, compared to those with a lesser disparity, children who had a greater verbal-perceptual disparity recalled more words in their first attempt at a learning task.

When the direction of influence was considered, results showed that children who had a disproportionately greater perceptual ability than verbal ability (as measured by the MA conversion of (VIQ - PIQ)) recalled more words than did their cohorts at the end of a learning task [r (36) = -.37, p = .014] (Figure 4) and overall during a learning task [r (36) = -.36, p = .015] (Figure 5). They also were able to "catch up" during a learning task, i.e., they recalled most words at the end of the task even though they may have recalled only a few words on their first attempt at the task [r (36) = -.28, p = .050] (Figure 6). Using the ratio [(VIQ-PIQ)/FSIQ], results additionally showed that children who recalled more words 30 minutes after completing a learning task also had perceptual ability disproportionately greater than verbal ability (as compared to their general ability, r (19) = -.40, p = .044).

Intellectual imbalance significantly correlated with errors in AV memory performance in two major ways. First, children with disproportionately greater

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[5]This correlation matrix has been omitted from presentation due to its extensive size. For additional information on this data, correspondence should be addressed to the author at her residence (see footnote 2).

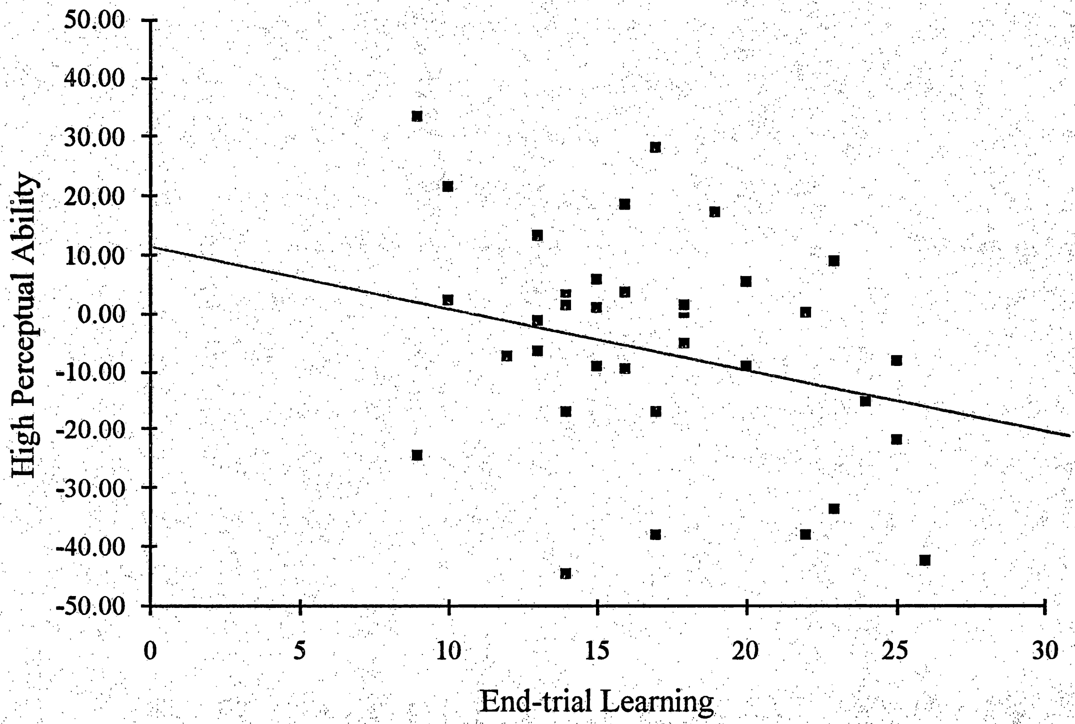

Figure 4. Relationship of high perceptual ability with end-trial learning ($\underline{n}$ = 36). The distribution reflects that as perceptual ability increased relative to verbal ability (or as (VIQ - PIQ) became more negative), more words were recalled at the end of a learning task.

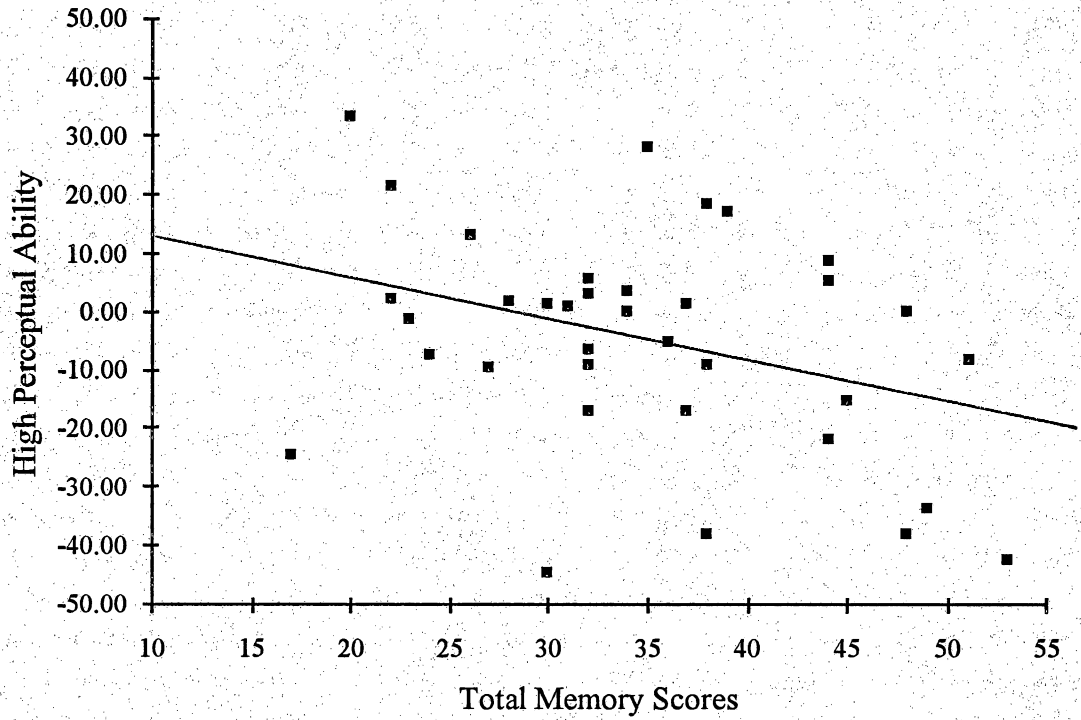

Figure 5. Relationship of high perceptual ability with total memory scores (n = 36). The distribution reflects that as perceptual ability increased relative to verbal ability (or as (VIQ - PIQ) became more negative), more words were recalled overall during a learning task.

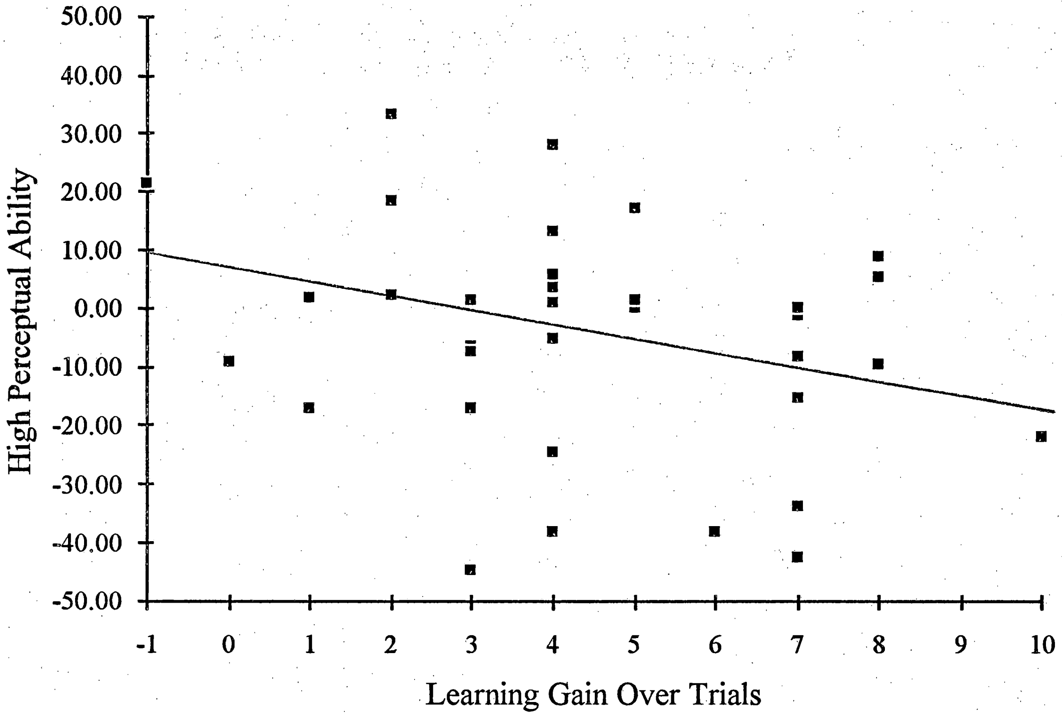

Figure 6. Relationship of high perceptual ability with learning gain over trials ($\underline{n}$ = 36). The distribution reflects that as perceptual ability increased relative to verbal ability (or as (VIQ - PIQ) became more negative), more words were recalled at the end of a learning task even though few words were recalled at the beginning of the task (i.e., more likely to "catch up") as shown by the solution to (Trial 5 - Trial 1) becoming more positive.

perceptual ability than verbal ability produced fewer first-trial intrusions (Figure 7); that is, they were less likely to recall words that had not actually been presented to them during the first session of a learning task [r (36) = .41, p = .007]. Second, they produced fewer false positives during recognition (Figure 8) meaning they were less likely to say they had heard a word previously during a learning task when they actually had not heard the word [r (17) = .42, p = .046].

In sum, results from analysis of the influence of intellectual imbalance showed that the direction of imbalance is essential to understanding AV memory performance. Children who were skilled in perceptual ability (i.e., had a perceptual ability disproportionately greater than their verbal ability) performed better at an AV memory task. Specifically, they (a) recalled more words overall, at the end of a learning task, and 30 minutes after a learning task; (b) "caught up" in their recall during a learning task (i.e., recalled most words at the end of the task even though they may have recalled only a few words on their first attempt at the task); and (c) produced fewer memory errors at the beginning of a learning task and during recognition.

Influence of attention. To test the hypothesis that children with greater attentional ability (i.e., longer attention spans) recall more words overall and produce fewer intrusions and false positives, attentional ability was defined in eight ways using

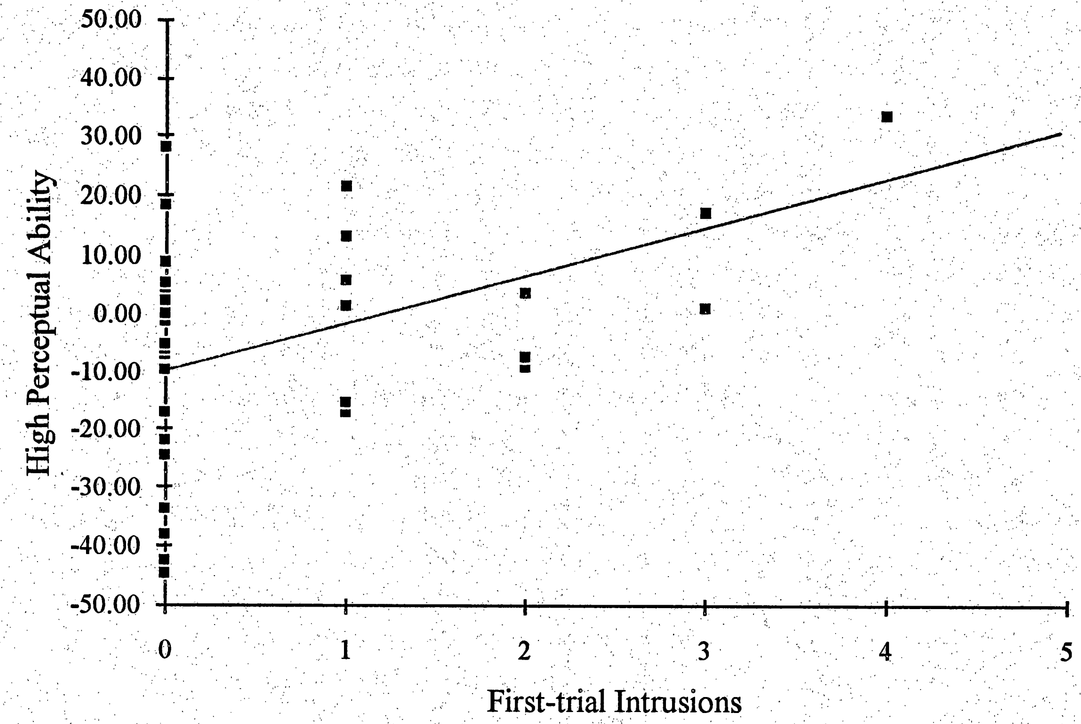

Figure 7. Relationship of high perceptual ability with first-trial intrusions ($\underline{n}$ = 36). The distribution reflects that as perceptual ability increased (or (VIQ - PIQ) became more negative), fewer first-trial intrusions were produced.

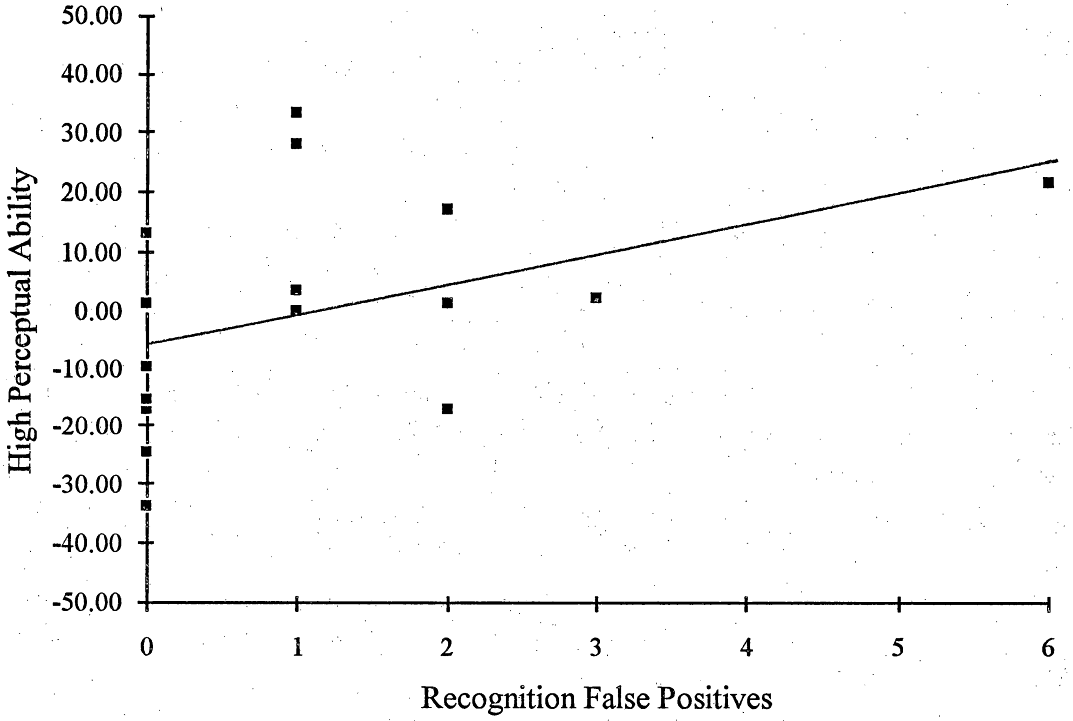

Figure 8. Relationship of high perceptual ability with recognition false positives ($\underline{n}$ = 36). The distribution reflects that as perceptual ability increased relative to verbal ability (or (VIQ - PIQ) became more negative), fewer recognition false positives were produced.

FDDQ[6]: (1) FDDQ, (2) (FDDQ/FSIQ) as an absolute measure of attentional ability as compared to general ability, (3) (FDDQ/VCDQ) as an absolute measure of attentional ability as compared to verbal ability, (4) (FDDQ/PODQ) as an absolute measure of attentional ability as compared to perceptual ability, (5) the corresponding MA conversion factor of FDDQ, (6) the corresponding MA conversion factor of (FDDQ/FSIQ), (7) the corresponding MA conversion factor of (FDDQ/VCDQ), and (8) the corresponding conversion factor of (FDDQ/PODQ). In addition, attentional ability was defined in three ways using the Conners indices of learning problems, impulsive/ hyperactive, and hyperactivity (i.e., behavioral measures from a parent rating scale).[7]

Separate Pearson product-moment correlation matrices were computed to compare these attention measures with correct AV memory performance and errors in AV memory performance.[8] The MA conversion of FDDQ (as a measure of attention) had the greatest number of significant correlations with correct memory performance--six of the eight measures (Table 4). More specifically, children with greater attentional ability recalled more words overall and more words at the beginning, at

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[6]Freedom from Distractibility Deviation Quotient (FDDQ) is a factor analytically derived index from the WISC-R. For further discussion of FDDQ, refer to p. 23.

[7]For further discussion of the Conners indices, refer to p. 24.

[8]These correlation matrices have been omitted from presentation due to their extensive sizes. For additional information on this data, correspondence should be addressed to the author at her residence (see footnote 2).

Table 4

Correlations Between Correct Memory Performance Scores and Attention

	Attention
First-trial Learning	.52***
End-trial Learning	.45**
Total Memory	.45**
Learning Gain	.24
Proactive Interference	.13
Retroactive Interference	.42*
Recognition Memory	.47*
Delayed-recall Memory	.53*

Note. Attention is measured by the mental age conversion of Kaufman's (1975) factor analytically derived Freedom from Distractibility Deviation Quotient (FDDQ). All memory performance measures have $n = 35$ except recognition memory ($n = 16$) and delayed-recall memory ($n = 18$) due to the limited availability of these items in the archival data.

*$p < .05$. **$p < .01$. ***$p < .001$.

the end, and 30 minutes after a learning task. They also had less problems with retroactive interference (i.e., they were able to still recall words from their initial learning task even after being interrupted with the presentation of a secondary word list) and recognized more words from a previous learning task.

The Conners indices (as measures of attention) significantly correlated with only proactive and retroactive interference (Table 5). In other words, children with greater attentional ability were more able (a) to recall words from a secondary word list after having spent time learning a previous list, and (b) to recall words from their initial word list after being interrupted with the presentation of a secondary word list. Of all the attention measures, only the Conners learning problems index significantly correlated with errors in AV memory performance (Table 6). Specifically, children who had difficulty attending to a task, i.e., they exhibited greater learning problems, (a) produced more intrusions than their cohorts at the end of a learning task (i.e., they recalled words that had not been formally presented to them), (b) were unable to decrease their errors by the end of the learning task (i.e., they produced more intrusions at the end of the task than at the beginning), and (c) produced more intrusions in trying to recall the initial word list after being interrupted with the presentation of a secondary word list (i.e., they produced intrusions after retroactive interference).

To summarize, results showed that attentional ability influenced AV memory

Table 5

Correlations Between Memory Interference Scores and Scores on the Conners Parent Rating Scale

	Learning Problems		Impulsive/Hyperactive		Hyperactivity	
	Raw	SD	Raw	SD	Raw	SD
Proactive Interference	.19	.28	.51**	.50**	.42*	.44**
Retroactive Interference	-.13	-.14	-.19	-.31*	-.19	-.16

Note. Raw = raw scores; SD = standard deviation scores. Due to the limited availability of archival data, all raw scores have $n = 23$ and all standard deviation scores have $n = 31$.

*$p < .05$. **$p < .01$.

Table 6

Correlations Between Errors in Memory Performance and the Learning Problems Index of the Conners Parent Rating Scale

	Learning Problems Index	
Errors	Raw[a]	SD[b]
End-trial Learning	-.36*	-.39*
Learning Gain	-.28	-.35*
Retroactive Intrusions	-.38*	-.02

Note. Raw = raw scores; SD = standard deviation scores.

[a]$n = 23$. [b]$n = 31$.

*$p < .05$.

performance. Compared to those with less proficient attention skills, children with proficient attention skills recalled more words during a learning task, had less problems with interference, and recognized more words from the learning task. In addition, they produced fewer intrusions at the end of a learning task and after retroactive interference.

<u>Building of regression models.</u> Stepwise regressions were performed to assess the relative contributions to prediction of AV memory performance by MA, age, intellectual imbalance (as measured by the MA conversion of (VIQ - PIQ)), and attention (as measured by the MA conversion of FDDQ). Table 7 shows the intercorrelations among the predictor variables. The dependent variables used were correct scores and error scores on the four memory performance measures of (a) first-trial learning, (b) total memory, (c) delayed-recall memory, and (d) recognition memory for a total of eight dependent variables. Table 8 shows the correlations between these dependent variables and the predictor variables.

Results yielded predictor variables entering only on step one for four of the eight equations. MA entered first for both the first-trial learning and total memory equations (Table 9). Attention entered first for the delayed-recall memory equation (Table 10). Intellectual imbalance entered first for the equation of errors in first-trial learning (Table 11). No significant levels of variance were accounted for by the remaining predictor variables in the four equations described above, and no predictor variables entered the equations for recognition memory and errors in total memory, delayed recall, and recognition.

Table 7

Intercorrelations Among the Predictor Variables

	2	3	4
1. Mental Age	.80***	-.24	.84***
2. Chronological Age	---	-.16	.71***
3. Intellectual Imbalance		---	-.11
4. Attention			---

***p < .001.

Table 8

Correlations Between Dependent Variables and Predictor Variables

	Correct Scores				Error Scores			
Dependent Variable	First-trial	Total	Delayed-recall	Recognition	First-trial	Total	Delayed-recall	Recognition
Mental Age	.49***	.45**	.30	.13	-.16	-.08	-.03	.02
Chronological Age	.30	.30	.16	-.05	-.14	-.15	.02	-.06
Intellectual Imbalance	-.22	-.31	-.23	-.10	.35*	.24	.14	.24
Attention	.48**	.40*	.32	.14	-.13	-.07	.03	-.00

Note. For first-trial scores and total scores, $n = 36$. For delayed-recall scores, $n = 19$. For recognition scores, $n = 17$.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 9

Stepwise Regression Summary Table for Mental Age Entered on Step One for First-trial Learning and Total Memory

R	R^2	F	β
	First-trial Learning		
.493	.243	15.422***	.493
	Total Memory		
.454	.206	12.438***	.454

***$p < .001$.

Table 10

Stepwise Regression Summary Table for Attention Entered on Step One for Delayed-recall Memory

R	R^2	F	β
.318	.101	5.384*	.318

*$p < .05$.

Table 11

Stepwise Regression Summary Table for Intellectual Imbalance Entered on Step One for Errors in First-trial Learning

R	R^2	F	β
.349	.122	6.656*	.349

*$p < .05$.

To summarize more specifically, MA accounted for a significant amount of variance in recall during the first attempt at a learning task and in recall overall during the five trials of a learning task. Likewise, attention accounted for a significant amount of variance in recall 30 minutes after completing a learning task, and intellectual imbalance (i.e., perceptual ability disproportionately greater than verbal ability) accounted for a significant amount of variance in recognition of a previously learned list of words.

Generalizability of clinical sample. AV memory performance scores from the out-patient (i.e., clinical) and nonclinical samples were assessed to determine the generalizability of the results from this study. First, one sample t-tests were computed comparing each sample to the hypothesized mean of zero for standard deviation scores. Specifically, a standard deviation score of zero on the Conners indices was considered a normal level of attention expected for a particular age group.[9] Results showed that nonclinical subjects' attention scores were not significantly different from the hypothesized mean of zero; whereas clinical subjects' scores were significantly different (Table 12). This means that nonclinical subjects were indeed more "normal" than clinical subjects because they had fewer problems in the areas of learning, impulsive/hyperactive, and hyperactivity.

Second, to assess whether the clinical and nonclinical subjects were of relatively equal intellectual ability, t-tests were computed to compare scaled scores

[9]Refer to p. 20 for a discussion of the controls implemented for attention within the nonclinical sample.

Table 12

Summary of One Sample T-tests Comparing Clinical and Nonclinical Subjects' Scores on the Conners Parent Rating Scale with a Hypothesized Mean of Zero

	Clinical		Nonclinical	
Conners Index	SD	t[a]	SD	t[b]
Learning Problems	2.91	8.84***	0.15	0.71
Impulsive/Hyperactive	0.98	4.29***	-0.20	-1.03
Hyperactivity	1.88	7.45***	-0.18	-1.15

Note. SD = standard deviation scores. The standard deviation scores listed are the mean score received for a particular group (i.e., clinical or nonclinical). The higher the score, the greater the behavior problem.

[a]df = 38. [b]df = 24.

***$p < .001$.

from the vocabulary subtest of the WISC-R (median loading on general intelligence $g = .80$, Sattler, 1990). No significant differences in vocabulary scaled scores were found, showing that clinical and nonclinical subjects were of relatively equal intellectual ability.

Third, t-tests were computed comparing the AV memory performance of clinical and nonclinical subjects by age group (e.g., 7-, 8-, 9-, 10-, and 11-year-olds). All age groups of clinical and nonclinical subjects (except 10-year-olds) performed relatively the same on the AV memory task. In other words, they recalled and recognized the same number of words and produced the same number of errors. The nonclinical 10-year-old subjects, however, performed significantly better than the clinical 10-year-olds on recognition [t (10) = -3.84, p = .003], end-trial intrusions[t (12) = 2.43, p = .032], and total intrusions [t (12) = 2.83, p = .015]. This means that compared to children from a clinical setting, children from a nonclinical setting recognized more words from a previous learning task and recalled fewer words that had not been formally presented (i.e., produced intrusions) both overall and at the end of the learning task.

To summarize, nonclinical subjects were significantly more "normal" in their attentional ability than were clinical subjects. Despite this difference, clinical and nonclinical subjects recalled and recognized basically the same number of words and produced the same number of errors in their AV memory performance when they were of equal age and intellectual ability. This means that the findings of this study (e.g., clinical subjects' performance on an AV memory task) can be generalized to a nonclinical child population at large.

DISCUSSION

Summary of Results

The foci and findings of both the primary and secondary analyses are summarized here to aid in the discussion of the implications of the present study.

Primary analyses. The present study had three primary foci--(a) the influence of age and intellectual ability on auditory verbal (AV) memory performance development, (b) the relationship between memory acquisition and memory errors, and (c) a comprehensive analysis of subjects' AV memory performance over trials. Six main findings resulted from these primary analyses:

1. Compared to those with a low mental age (MA), children with a high MA (a) recalled more words overall; (b) recalled more words at the beginning, at the end, and 30 minutes after completing a learning task; and (c) recognized more words from the learning task.

2. Compared to those who were unable to "catch up," children who were able to "catch up" in a learning task (i.e., recalled only a few words at the beginning but most words by the end) produced few memory errors in both recall and recognition.

3. Compared to their cohorts, children who recalled more words overall during a learning task produced fewer memory errors during the learning task.

4. Compared to their cohorts, children who produced more memory errors 30 minutes after a learning task recalled fewer words 30 minutes later and had more proactive and retroactive interference.

5. Compared to their cohorts, children who recalled more words 30 minutes

after a learning task also recalled more words overall and at the end of the task, "caught up" during the task, and recognized more words from the task.

6. Compared to their cohorts, children who produced more memory errors at the beginning of a learning task also produced more errors overall, at the end of the task, and 30 minutes after the task.

Secondary analyses. The present study examined four areas of secondary interest--(a) the influence of intellectual imbalance on AV memory performance, (b) the influence of attention on AV memory performance, (c) the building of regression models to explain the process of AV memory performance over trials, and (d) the generalizability of findings from a clinical sample to a non-clinical sample. Four main findings resulted from these secondary analyses:

1. Compared to their cohorts, children who were skilled in perceptual ability (i.e., had a perceptual ability disproportionately greater than their verbal ability) performed better at an AV memory task. Specifically, they (a) recalled more words overall, at the end of a learning task, and 30 minutes after a learning task; (b) "caught up" in their recall during a learning task (i.e., recalled most words at the end of the task even though they may have recalled only a few words on their first attempt at the task); and (c) produced fewer memory errors over trials, at the beginning of a learning task, and during recognition.

2. Compared to those with less proficient attention skills (i.e., shorter attention span), children with proficient attention skills recalled more words during a learning task, had less problems with interference, and recognized more words from

the learning task. In addition, they produced fewer intrusions at the end of a learning task and after retroactive interference.

3. In stepwise regression analysis, MA accounted for a significant amount of variance in recall during the first attempt at a learning task and in recall overall during the five trials of a learning task. Likewise, attention accounted for a significant amount of variance in recall 30 minutes after completing a learning task, and intellectual imbalance (i.e., perceptual ability disproportionately greater than verbal ability) accounted for a significant amount of variance in recognition of a previously learned list of words.

4. Despite a difference in attentional ability, clinical and nonclinical subjects recalled and recognized basically the same number of words and produced the same number of errors in their AV memory performance when they were of equal age and intellectual ability. This finding suggests that the results of this study on clinical subjects' AV memory performance can be generalized to a nonclinical child population at large.

Implications of Results

Primary results. Results from the present study confirm the hypothesis that AV memory performance improves as age and intellectual ability increase, supporting the findings of Forrester and Geffen (1991) and Geffen et al. (1990). However, these results go beyond that of Forrester and Geffen and Geffen et al. by revealing a more marked difference in performance when a "pure" measure of ability such as mental age (MA) is used. To recapitulate, the age range of the clinical sample used in this study is quite narrow (7 to 11 years); however, the MA range is greatly expanded (5 to 13 years), providing a sample with a more diverse range of ability. As expected, results clearly show that MA (when MA is categorized into groups) accounts for a greater number of significant differences in AV memory performance. More specifically, MA significantly correlates with five of the eight memory performance measures, and age and IQ significantly correlate with only two of the eight memory performance measures. Further research needs to include MA as an independent variable influencing AV memory performance rather than just using mere chronological age and intelligence, for oftentimes children may not be performing at a level equal to their age (i.e., their MA and chronological age are not equal). For example, a child in third grade and 8-years-old may actually be performing at a level of first grade and 6-years-old or at a level of fifth grade and 10-years-old. Applying the clinical diagnostic tool of MA to the area of AV memory performance is then vital in targeting those children who need academic help.

Contrary to the general findings of Robinson and Kingsley (1977), results show that general intellectual ability, as measured by FSIQ and its mental age conversion, does not account for differences in the number of memory errors produced in an AV memory task. However, differences in the number of memory errors result when general ability is broken down into verbal and perceptual ability. Specifically, perceptual ability significantly influences the number of errors occurring in the first attempt at recalling a word list. Although not formally stated in the literature, it seems logical that verbal ability would be indicative of verbal memory performance. On the contrary, results indicate that perceptual ability is indicative of verbal memory performance. Specifically, children who are more adept at visually representing objects, designs, and patterns produce fewer memory errors (i.e., are less likely to recall words that are not formally presented to them). Auditory verbal memory then must involve the process of visual representation during the storage of information for a memory performance task. Wiens, McMinn, and Crossen (1988) allude to this point in their research with adults which found both verbal and perceptual ability to significantly correlate with correct memory performance. However, no studies in the literature attempt to address the relationship of verbal and perceptual ability with errors in memory performance as it has been addressed in the present study. Should future research support the finding that perceptual ability and AV memory performance are positively related, clinicians then have the venue to assess AV memory by targeting children with depressed perceptual ability. On a more common scale, teachers can help children who have difficulty storing and retrieving information from class lessons presented verbally. Should these same children have difficulty replicating objects and designs presented visually, remedial programs focusing on enhancing perceptual skills could be implemented to aid the children in their development of efficient AV memory skills.

The best avenue to understanding the process of AV memory performance is looking at the performance itself, both by comparing correct performance and errors in performance and by evaluating how the aspects of performance covary within itself. Previous studies using the Auditory Verbal Learning Test (AVLT) have acknowledged the presence of AV memory errors (Forrester & Geffen, 1991; Geffen et al., 1990) but have neglected to investigate how these errors covary with overall performance. In contrast, results from the present study show that children with good recall ability have good control over their production of memory errors. More specifically, results confirm the hypothesis that as recall increases, memory errors decrease.

Implications from the relationship of correct AV memory performance with intellectual ability can be applied to this relationship of correct performance with errors in performance. To explain, general AV memory theory suggests that intrusions may be a result of an inability to use memory recall strategies appropriately (Shindler, Caplan, & Hier, 1984). Are not children aged 7 to 11 years in a formative stage of developing their learning strategies? As children grow older, do they not become more proficient in their usage of learning strategies? According to Friedrich (1974), learning strategy proficiency is reflected in increased age and intellectual ability which in turn is reflected in a decrease in the production of intrusions. One could infer then that targeting children with depressed intellectual ability (i.e., those with less proficient learning strategies) and children who produce numerous AV memory errors addresses a similar population. Clinicians may find this helpful in assessing a child with academic problems that are not clearly definable. Having two ways in which to approach what may be a similar problem (i.e., assessing intellectual ability and AV memory performance) provides a greater probability of determining a helpful course of treatment. Such treatment might include training in the development of proficient learning strategies in addition to training how to implement these strategies during an AV memory task. In other words, clinicians can help children learn which strategy is appropriate and how to use it when information is presented verbally. This allows the children to efficiently store the information, thus increasing the chances for efficient retrieval of the information at a later time.

Future research can aid clinicians in diagnosing children who produce numerous AV memory errors. Just as the present study expanded on previous studies by investigating how memory errors covary with overall AV memory performance, future studies can expand further by analyzing the types of errors. For example, future AVLT studies can address issues raised by general AV memory research such as the repetition of intrusions across trials (i.e., incorrectly recalling the same word on each subsequent trial) and the semantic, phonemic, or acoustic similarity of intrusions and false positives to words in the task list.[10] Such future investigations would provide an even deeper understanding of AV memory errors.

In addition to revealing the relationship between correct AV memory performance with errors in AV memory performance, results confirm that the AVLT reflects a single process over trials. In other words, children who recall many words at the beginning of a learning session also recall many words at the end of the learning session and retain many words in recall 30 minutes later. Likewise, children who produce few errors at the beginning of a learning session also produce few errors

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[10]Refer to studies by Drewnowski and Murdock (1980), Lee et al. (1988), and Underwood (1982) discussed on p. 8.

at the end of the learning session and 30 minutes later. This information is invaluable to clinicians, for it enables them to detect performance trends early in the assessment process. Obviously, final conclusions about a client cannot be drafted until a thorough assessment is completed. However, the AVLT provides valuable information allowing problem areas to be targeted in a timely fashion.

Secondary results. The four areas of secondary analysis each generate their own implications. First, the present study hypothesized that greater intellectual imbalance yields poor AV memory performance. In other words, as children's perceptual and verbal abilities become more disparate (i.e., one skill is better than the other) it was expected that children would exhibit more problems learning a list of words, recall and recognized fewer words overall, and produce more errors in memory performance. Results did not support this assertion. On the contrary, as the absolute value of disparity between perceptual and verbal abilities increases, AV memory performance improves. More specifically, the direction of imbalance must be considered. When children's perceptual ability is disproportionately greater than their verbal ability, recall increases and errors decrease. The issue then is not mere imbalance, but whether or not perceptual ability is proficient enough to perform an AV memory task. This basically reiterates the primary finding that as perceptual ability increases, the number of AV memory errors significantly decreases. Perhaps children with mere intellectual imbalance should not be the ones targeted then by clinicians during assessment. Rather, children who have depressed perceptual ability should be targeted because it is these children who do not have the proficiency in visually representing objects and designs to aid them in AV memory performance. However, before such an assertion as to the principal importance of perceptual ability can be applied, further research needs to address this issue in more detail.

Second, the present study asserted that intellectual ability and age are not sufficient to predict AV memory performance. Although previous studies on the AVLT have not included such, attentional ability must also be addressed. As expected, results confirm that as attentional ability increases (i.e., longer attention span), recall increases and errors decrease. This supports general memory theory which suggests that an individual must be able to attend to a learning situation in order to properly encode, store, and thus retrieve information (Anderson, 1990; Wellman, 1988).

Third, results confirm that MA, intellectual imbalance, and attention account for significant levels of variance in AV memory performance; however, due to high intercorrelations among the predictor variables, stepwise regression models were not developed beyond step one. Perhaps in future research, hierarchical regression can produce a more clear model explaining AV memory performance. Stepwise regression capitalizes on sampling error; whereas, hierarchical regression specifically tests a proposed model of relative contribution to AV memory performance.

Finally, results confirm the hypothesis that despite differences in attentional ability, clinical and nonclinical subjects' AV memory performance is not significantly different. This suggests that the differences in AV memory performance found when comparing differing levels of attentional ability are confounded by the high intercorrelations among MA, age, and attention (refer to Table 7). Since the clinical and nonclinical subjects' AV memory performance are not significantly different, the information gained from the present study can be generalized to the child population at large as long as the children are equal in age and intellectual ability to the clinical sample used. This generalization enables researchers to develop academic programs not only for private clinics but for public schools as well.

Limitations of the Present Study

As with any research, the present study provides a very narrow examination of auditory verbal (AV) memory performance. Its largest limitation is its use of archival data. Archival data allow the researcher to circumvent recruiting, testing, and debriefing subjects by allowing the research to be accomplished more expeditiously. However, it also leaves the researcher with problems that are often irreparable, for the researcher is purely at the mercy of the data. Missing or miscalculated data can never be recovered, and equal sample sizes cannot be obtained. Thus, the researcher must utilize existing data.

The results of the present study reveal very definite relationships within AV memory performance, providing a foundation upon which future research can be based. However, the data used did not have equal numbers of males and females for each age group, and the sample size per age group was quite small (e.g., n = 10-15). Such weaknesses pose important questions for future studies. Should subjects be recruited from the general population, controlling for an equal number of subjects for each group? If so, does this not involve an enormous amount of time for data collection, not to mention an enormous amount of money? Perhaps the solution then is to control the availability of archival data. For example, using several clinical sources from which to collect data may be a more efficient method for future research.

CONCLUSIONS

Since school-aged children spend much of their time in controlled learning environments (i.e., school), it is important to investigate the processes involved in such situations. Children are required to learn new concepts, vocabulary, and information through exposure to successive days of lectures. In essence, they learn verbal information audibly (i.e., by hearing it).

The Auditory Verbal Learning Test (AVLT) mirrors this school environment, providing insight into the process of auditory verbal (AV) memory. Results of this study show that children with good recall ability have good control over their production of memory errors. Specifically, children who recall many words from an AV learning task produce few memory errors during that task. Further, children's performance during the first learning trial is indicative of later performance.

Continued assessment of the process of AV memory, especially the influence of errors in AV memory, is imperative for the development of AVLT norms. These norms need to reflect not only memory performance on the AVLT, but they need to reflect performance by varying levels of general intellectual ability (i.e., mental age) and verbal and perceptual ability. The establishment of such norms will enable clinicians to target children with learning problems and provide a better understanding of the process of AV memory. This understanding is valuable to the development of remedial academic programs which can enhance learning strategy proficiency, storage of AV information, and later retrieval of that information.

APPENDIX A

Rey Auditory Verbal Learning Test

List A	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
1. Drum					
2. Curtain					
3. Bell					
4. Coffee					
5. School					
6. Parent					
7. Moon					
8. Garden					
9. Hat					
10. Farmer					
11. Nose					
12. Turkey					
13. Color					
14. House					
15. River					
Total Correct					
Total Errors					

Rey Auditory Verbal Learning Test (continued)

List B	Trial 6	List A	Trial 7	Delay
1. Desk		1. Drum		
2. Ranger		2. Curtain		
3. Bird		3. Bell		
4. Shoe		4. Coffee		
5. Stove		5. School		
6. Mountain		6. Parent		
7. Glasses		7. Moon		
8. Towel		8. Garden		
9. Cloud		9. Hat		
10. Boar		10. Farmer		
11. Limb		11. Nose		
12. Gun		12. Turkey		
13. Pencil		13. Color		
14. Church		14. House		
15. Fish		15. River		
Total Correct		-----		
Total Errors		-----		

Note. This version of the Auditory Verbal Learning Test is a modification by Wallace T. Cleaves, Ph.D., Claremont, California.

APPENDIX B

Word List for Testing Recognition in the Auditory Verbal Learning Test

Bell (A)	Coffee (A)	Farmer (A)
Window (SA)	Mouse (PA)	Rose (SPA)
Hat (A)	River (A)	Cloud (B)
Barn (SA)	Towel (B)	House (A)
Ranger (B)	Curtain (A)	Stranger (PB)
Nose (A)	Flower (SA)	Garden (A)
Weather (SB)	Color (A)	Glasses (B)
School (A)	Desk (B)	Stocking (SB)
Hand (PA)	Gun (B)	Shoe (B)
Pencil (B)	Crayon (SA)	Teacher (SA)
Home (SA)	Church (B)	Stove (B)
Fish (B)	Turkey (A)	Nest (SPB)
Moon (A)	Fountain (PB)	Children (SA)
Tree (PA)	Boat (B)	Drum (A)
Balloon (PA)	Hot (PA)	Toffee (PA)
Bird (B)	Parent (A)	Lamb (B)
Mountain (B)	Water (SA)	

Note. A = words from list A; B = words from list B; S = word with a semantic association to a word on list A or B as indicated; P = word phonemically similar to a word on list A or B as indicated.

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