SENSORY AND COGNITIVE PROCESSING DEFICITS IN ANXIOUS DEPRESSED CHILDREN: A NEUROBEHAVIORAL STUDY

by

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(ABSTRACT)

The neurobehavioral effects of anxiety and depression on functional systems of the right posterior and left frontal regions were measured in two groups of 9 to 11 year old boys to determine whether children exhibit processing and motor deficits similar to those found in previous studies of depressed adults. Individuals with a prior history of anxiety, depression, learning disability or Attention Deficit Hyperactivity Disorder were eliminated from participation. One group was classified as high in depression and anxiety based on cut-off scores on the Child Depression Inventory, and the Trait scale of the State-Trait Anxiety Inventory for Children, respectively. The other group was classified as low in depression and anxiety using the same measures. Group performance was compared on measures of auditory identification of affective prosody (happy, sad, angry, and neutral), hemispheric lateralization of affective and propositional speech, grip strength, verbal fluency, problem solving, and alternation and sequencing. As

predicted, anxious-depressed subjects performed less accurately on the identification of happy, sad, and angry affective prosody in congruent and incongruent conditions, were relatively less lateralized on both dichotic listening and grip strength measures, Further, anxious depressed children were less proficient than non-anxious, non-depressed children on measures of frontal executive functioning, including verbal fluency, problem-solving, and alternation, but not on measures of sequencing.

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DEDICATION

In memory of Alice Marion Wright, who
taught me by example how to love children,
how to work and play, and most of all,
to believe in myself. Thanks, Mom...

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Chapter I

Introduction and Purpose of the Investigation

Introduction

Depression in children has been recognized clinically for over 60 years. Kasanin (1931) described affective psychosis in children, hypothesizing the importance of "constitutional" factors such as resiliency. Somewhat later, Spitz and Wolf (1946) noted anaclitic depression in infants, observing the protest, despair, and ultimate detachment of those infants who sustained the loss of a primary caretaker. Despite early observation that young children exhibited symptoms similar to those of depressed adults, there was no widespread acknowledgment of depression as a childhood disorder (e.g., Lefkowitz & Burton, 1978; Rutter, Izard, & Read, 1986). During the 1970's, depression became a topic of greater interest within the clinical and research communities and study increased significantly. Since that time investigators have focused on defining the parameters of the disorder, including symptomatology, etiology, incidence, prevalence, assessment, and treatment. While these areas continue to be important, there has been little investigation of the effects of depression on children's cerebral functioning. Studies of depressed adults have found deficits in a number of functional systems including

auditory perception (Bruder, Quitkin, Stewart, Martin, Voglmaier, & Harrison, 1989), timed motor response (Nelson & Charney, 1981; Weckowicz, Nutter, Cruise, Yonge, & Cairnes, 1978), cognitive processing speed and efficiency (Newman & Sweet, 1986; Rush, Weissenburger, Vinson, & Giles, 1983; Shipley, Kupfer, Spiker, Shaw, Coble, Neil, & Cofsky, 1981), attention and motivation (Abrams & Taylor, 1987; Adams, Craig, & Parsons, 1986; Cohen, Weingartner, Smallberg, Pickar, & Murphy, 1982; Lezak, 1983), visuospatial functioning (Gray, Dean, Ratten & Cramer, 1987), and memory and learning (Frith, Stevens, Johnstone, Deakin, Lawler, & Crow, 1983; Kopelman, 1986; Weingartner, Cohen, Murphy, Martello, & Gerdt, 1981).

There are several reasons why it is important to investigate potentially similar effects in children. First, developmentalists have based much current inquiry on the premise that development is a highly interactive process among variables, with each contributing to an overall outcome. One developmental neuropsychologist noted that "Children's intellectual and motor development relies on a continuous bidirectional process of informational input and response output among perceptual, attentional, memory/learning, motoric, and executive functioning systems" (Hynd & Semarud-Clikeman, 1989, p. 205). A fundamental assumption of this theory of development is that a given

system is linked to the development of other related systems. If one concurs with this widely accepted developmental approach, deficits in depressed children similar to those which have been found in depressed adults might be expected to have negative implications far beyond the specific effect on a particular system. Hypothetically, depression might affect a child's total cognitive experience, including the areas of academic learning, social relationships and adaptive behavior. This, in turn, could have an increasingly pervasive negative effect on the child's perception of himself and his personal competence. One of the foremost investigators of depression in children, Kovacs (1989), argued that "depression directly affects children's abilities by disrupting the development of age-appropriate competencies, including slowed cognitive development and lower subsequent achievement" (page 25).

Second, the fact that there exists a paucity of studies pertaining to the neuropsychological effects of depression in children is compounded by the fact that those which do exist have focused, for the most part, on inpatient psychiatric populations. Such children frequently exhibit a variety of comorbid conditions including learning disabilities, Attention Deficit Hyperactivity Disorder, and Conduct Disorder. While depression does tend to be more prevalent in these populations, the potential is great for

confounding factors in the research data. Study of the effects of depression and anxiety on a population of public school children not previously identified at risk may be an important first step in quantifying and qualifying the effects of these disorders within a relatively unconfounded population of preadolescent children. Such is the aim of this study.

Given the aforementioned problems, it is pertinent to question an appropriate starting point, particularly since developmental psychologists have argued against superimposing adult research over child behavior. This reluctance to apply adult data to children is partially based on the awareness that similar disorders may have vastly different outcomes for the developing child, depending upon where the child is in the developmental process. While the potential relationship between adult and child behavior research must be investigated with care, the substantially greater number of studies which focus on depressed adults may provide important hypotheses for the study of similar questions about children. In addition, research on adult populations has provided the basis for current widely accepted neuropsychological theory and practice involving neural networks of communication within the brain, commonly referred to as functional systems (Luria, 1973). Therefore, the available data on cortical

function in depressed children will be reviewed in conjunction with the more prevalent neuropsychological research on adults. This approach will also serve to provide an empirical foundation of neuropsychological principles of function, and will serve to develop a theoretical basis for the measures and expected outcomes of the present study.

Chapter II

Review of Literature

The lack of research on the neurocognitive performance of depressed children is not surprising considering that until recently, neuropsychologists continued to debate the impact of depression on cognitive functioning in adults. As currently as 1985, Reitan and Wolfson observed that "a severe and clinically significant degree of depression . . . usually seem(s) to be irrelevant to interpretation of neuropsychological test findings" (page 6). Despite the sweeping nature of this conclusion, early neuropsychological studies of depressed adults were infrequent. Heaton, Baade, and Johnson (1978) reviewed 94 studies of adult psychiatric patients, published between 1960 and 1975, to assess the efficacy of neuropsychological tests in discriminating between psychiatric disorders and organically based conditions. Only two studies in this group included depressed individuals, with the majority of the research focusing on individuals with schizophrenia. Similarly, Miller (1975) comprehensively reviewed over 75 studies of psychological deficits in adults with depression, published between 1922 and 1975. Only 12 of the studies cited were related to specific domains of neuropsychological functioning. Since that time, neuropsychological research on adult subjects has increased substantially. A number of

investigators have recognized that functional deficits observed in depression are similar to those found as a result of specific brain lesions. Further, an increasing number of adult studies suggest that depression can significantly affect neuropsychological test performance. Prior to discussing studies of depression, it is important to review the fundamental concept of functional systems.

Cerebral Organization

The principle that brain function mediates behavior is basic to neuropsychology. Compatible with this concept is the premise that neural activation is essential to the processing of sensory information from the organism's environment. It is well accepted that information processing within the cerebrum is organized by functional systems (Anokhin, 1940). The term refers to interactive neural networks, preferentially activated in response to certain types of stimuli or certain mental processes. Thus neuronal systems communicate with, and receive feedback from, other neuronal systems in the decoding and processing of incoming stimuli, and the organizing and monitoring of outgoing responses (Luria, 1973).

One important basis for the differentiation of functional systems which is central to the investigation of depression is hemispheric laterality, that is, specialization of a function or activity on one side of the

organism. Such laterality is observed in asymmetries of motor, perceptual, and cognitive functions (Henninger, 1992). Specifically, verbal processes, sensory, and motor functions on the right side of the body are primarily lateralized to the left hemisphere. In contrast, nonverbal, visuospatial processes, and sensory and motor functions on the left side of the body are lateralized to the right hemisphere. It is also widely accepted that the two hemispheres process information differently. The left hemisphere is activated when logical, sequential, or detail-oriented operations are required, while the right hemisphere is activated during holistic, integrative, and/or conceptually based processing (Levy, 1969; Tucker, 1981).

In addition to lateralization of function, the brain is further organized into anterior and posterior regions. Activation of anterior left and right hemispheres has been associated with outgoing motor response, including verbal and nonverbal expression respectively, while posterior left and right regions are activated in sensory perception and comprehension of incoming verbal and nonverbal communication. More specifically, posterior regions of the right hemisphere are essential for the accurate decoding of all types of nonverbal information, including facial expression, gestures, and prosody (i.e., the tone, rhythm, and inflection with which a message is delivered (Heilman,

Schwartz & Watson, 1978; Heilman & Van Den Abell, 1979; Vrtunski, Kim, & Boller, 1985).

Additionally, investigators have found that decreased right posterior activation is associated with decreased activation across the cerebrum (e.g., Heilman & Van Den Abell, 1979; Heilman, Bowers, & Valenstein, 1985; Heller, 1990; Heller, 1993) reflecting the important role of this region in generalized central nervous system arousal-activation. Heilman and Van Den Abell (1979) measured reaction time in the presence of a warning stimulus projected to either the right or left hemisphere. Results showed that warning stimuli projected to the right hemisphere reduced reaction times of the right hand even more than warning stimuli projected directly to the left hemisphere. The authors argued that the two hemispheres have different patterns of responding, whereby "the left hemisphere performs at an initially high level then declines" while the right hemisphere performs at a somewhat lower, but consistent level of activation. They concluded that "each hemisphere can mediate its own activation, and that the right hemisphere can mediate for the left hemisphere better than the left hemisphere can activate for the right hemisphere" (p. 319). Thus, in the presence of right hemisphere dysfunction, a decrement in generalized sustained activation would be predictable across all

functional systems. This may have important implications for the following discussion about patterns of brain dysfunction observed in depression.

Functional Deficits in Brain Injury and Depression

Behavioral observation of individuals with documented brain lesions has provided a foundation for the understanding of basic brain-behavior relationships, as well as guiding research on depression. Such studies revealed that lesions in specific areas were correlated with marked affective change, including the appearance of depression, anxiety, or indifference. The type of affect involved was dependent upon the specific area of the brain which was affected. Patients with left hemisphere lesions, particularly at the far-frontal pole, frequently demonstrated what has been termed a "depressive-catastrophic response" (Goldstein, 1948) which includes hopelessness, extreme sadness, and tearfulness. In a study of the behavioral correlates of cortical lesions in specific areas (Robinson, Kubos, Starr, Rao, & Price, 1984), proximity of the lesion to the left frontal pole was positively correlated with severity of depression. Additionally, decreased arousal in the right posterior region of the brain was noted in the same patients. Gainotti (1972) investigated the effects of lesion location on specific symptoms, with the consistent finding that left hemisphere lesions were

associated with depressive catastrophic reactions, while right hemisphere lesions were accompanied by indifference, joking, and minimization of deficits. Heilman, Scholes, and Watson (1975) measured the effect of either right or left temporoparietal lesions on patients' ability to judge the content and affect of spoken messages. The results indicated that those with right temporoparietal lesions performed significantly less accurately on the affect variable, while those with left temporoparietal lesions were less accurate on the content variable. Other studies (Ross & Mesulam, 1979; Tucker, Watson, & Heilman, 1976) have demonstrated that right hemisphere dysfunction impairs patients' ability to convey and interpret nonverbal communication, including affective prosody (the pitch, rhythm and stress which conveys nonverbal meaning), facial expression, and gesture. Research on adults with unilateral lesions has consistently shown that an intact right hemisphere is essential for the accurate production and interpretation of emotionally valenced stimuli, whether verbal or visual (Ross & Mesulam, 1979; Sackheim, Gur, & Saucy, 1978; Tucker, et al., 1976).

Studies of Depression

Studies of depressed individuals have noted that they exhibit patterns of functional deficits which are lateralized similarly to those found in patients with left frontal and/or right posterior lesions. Such studies have

been based on electroencephalographic (EEG) recordings, dichotic listening procedures, positron emission tomography (PET) scans, and neuropsychological assessment.

EEG/PET scan studies.

A relatively large body of adult research based on EEG recordings (e.g., Davidson, Schwartz, Saron, Bennett, & Goleman, 1978; Flor-Henry, Koles, Howarth, & Burton, 1979; Perris & Monokov, 1979; Perris, Monakhov, Von Knorring, Botskarev, & Nikiforov, 1978; Schaffer, Davidson, & Saron, 1983; Tucker, Stenslie, Roth, & Shearer, 1981) has been useful in identifying regions of abnormality in hemispheric activation which are associated with negative affective states in depressed individuals. For example, Henriques and Davidson (1991) recorded differential levels of baseline EEG in depressed individuals, as compared to normal controls. Data revealed relatively greater activation of the right frontal region, compared to that of the left frontal region in subjects with a history of depression. A trend toward lower right posterior activation was also observed. Similarly, Davidson, et al. (1978) compared activation of anterior left and right regions during positive and negative affective responses, observing that relatively greater anterior right than left activation was associated with negative affect, while the pattern was reversed for positive affect. Perris and Monakhov (1979) also found higher levels

of activation in the right frontal region (relative to left), to be directly correlated with depressive affect, as did also D'Elia and Perris (1973).

A number of other studies of clinically depressed adults (D'Elia & Perris, 1973; Flor-Henry, 1979; Matousek, Capone, & Okawa, 1981), have found reduced EEG activation in right parietal regions. Abrams and Taylor (1979) compared the EEGs of depressed patients to those of schizophrenic patients, finding significantly greater right parieto-occipital abnormal slow wave activity, which is indicative of lower levels of arousal, in the depressed group than in the schizophrenic group. Unfortunately, a normal control group was not included in the study. Other investigators (e.g., Tucker, et al., 1981) experimentally induced depression in normal college students, finding less vivid mental imagery during the depressed state, suggestive of decreased right posterior activation. In a subsequent phase 2 of the study, EEG recording demonstrated lower left frontal activation, relative to right frontal during a depressed mood. These findings suggested that anterior and posterior regions were activated differently within a given hemisphere. Taken together, EEG studies tend to support a model of decreased right posterior activity during a depressed state, with relative decreases in left frontal activity, and increased right frontal activity.

PET scans have demonstrated lower levels of glucose utilization in the right temporal lobe of depressed patients (Post, DeLisi, Holcomb, Uhde, Cohen, & Buchsbaum, 1987), and in posterior regions of the right hemisphere (Uydenhoef, Portelange, Jacquay, Charles, Linkowski, & Mendlewicz, 1983). Additionally, both EEG and PET studies of depressed individuals have found evidence of diminished generalized cerebral activation over both hemispheres (Baxter, et al., 1985; Heller, 1990; Schaffer, et al., 1983). This is consistent with other research which shows that decreased right parietal activation in depression is associated with a general reduction in overall cerebral arousal.

Dichotic listening studies.

Dichotic listening is an established neuropsychological procedure used to measure relative hemispheric activation. The technique was first conceived by Broadbent (1956) as an experimental means of investigating a mechanical model of memory in adults. Since that time, it has been used frequently to investigate the lateralization of verbal and nonverbal communication. In the dichotic listening paradigm, subjects are asked to listen to two competing messages simultaneously, one at the right ear (which goes primarily to the left hemisphere) and the other at the left ear (which goes primarily to the right hemisphere). A majority of normal individuals demonstrate faster and more accurate

reporting of verbal information received by the right ear, which has been taken as evidence of posterior left hemisphere superiority for receptive verbal processing.

Kimura (1961a) first used dichotic listening to assess the laterality of auditory processing, and reported the results in a series of papers. This investigator demonstrated that epileptic patients who exhibited left-lateralized language, observed through Wada testing (Wada & Rasmussen, 1960), were more accurate in recalling verbal items when presented to the right ear (left hemisphere) while those with right lateralized language were more accurate at the left ear. The effect occurred independent of the patient's handedness. In a second study (Kimura, 1961b) the dichotic listening technique was used to demonstrate that a majority of individuals showed a right ear advantage for language. Dichotic listening studies using adults have generally demonstrated a similar right hemisphere advantage for the processing of affectively valenced nonverbal stimuli such as, tone patterns (Bryden, Ley & Sugerman, 1982), melodies and nonverbal sounds such as, laughing or crying (Carmon & Nachshon, 1973; Kimura, 1966), and affective prosody (Haggard & Parkinson, 1982; Ley & Bryden, 1982).

In the first investigation of dichotic listening in children, using digit names as stimuli, Kimura (1963) found a significant right ear advantage for verbal material which

was present by age 6, and did not increase, developmentally, over time. Knox and Kimura (1970) dichotically presented environmental sounds (e.g., clock ticking, car starting) and animal sounds, as well as digits, to children 5 to 8 years of age, requesting them to name the sounds or digits. A significant left ear advantage for environmental sounds was confirmed, in conjunction with a right ear advantage for verbal material. A left ear trend was observed for animal sounds, but did not reach significance. These investigators concluded that the right hemisphere shows specialization for the processing of nonverbal information by age 5 years, with the magnitude of the effect remaining consistent across the age range. Piazza (1977) reported similar findings with a sample of children 3, 4, and 5 years of age. Kraft (1984) used a protocol with young children which required them to point to responses rather than articulating them. Similar to Knox and Kimura (1970), the study found significant laterality for environmental sounds (left ear) and for digit names (right ear) in children from dextral families. A number of subsequent dichotic listening studies which included children utilized linguistic stimuli and free report (Berlin, Hughes, Lowe-Bell, & Berlin, 1973; Bissel & Clark, 1984; Kinsbourne & Hiscock, 1977; Obrzut, Hynd, Obrzut, & Leitgeb, 1980). These studies also failed to show significant age-related changes in the right ear advantage.

However, one study (Bakker, Hoefkens, & Van der Vlugt, 1979) investigated the longitudinal development of laterality using dichotically presented verbal stimuli. The procedure was administered to school children on four separate occasions over a five-year period, beginning at an average age of 6 years. These investigators found a significant right ear advantage, together with a significant age-related increase in performance. Despite the differing findings of Bakker et.al. (1979) there is general agreement among most investigators that little change occurs in the lateralization of verbal processing after the preschool years.

While lateralized brain function has been extensively studied in normal adults and children using dichotic listening, relatively few studies have employed the technique to assess laterality in depressed subjects. The majority of these studies has used consonant/vowel (CV) syllables (e.g., ba, ga), generally demonstrating a right-ear advantage for words which is similar to, or better than that shown by nondepressed subjects. Bruder, et al. (1989) compared adults diagnosed with melancholic depression (characterized by sadness and vegetative symptoms) to those with atypical depression (reactivity of mood with preserved pleasure capacity) and normal controls on a dichotic listening task using consonant vowel (CV) syllables, and

complex tones. Melancholic depressives exhibited a larger right-ear advantage for CV syllables than either atypical depressives or normal controls. Melancholic depressives also had a right ear advantage for complex tones, a reversal of the expected pattern of laterality. A number of other investigators have also failed to find the expected left-ear advantage for musical tones, or a click detection task (frequently used as a measure of right hemisphere functioning), present in normal control groups (Berger-Gross, Bruder, Quitkin & Goetz, 1985; Johnson & Crockett, 1982; Yozawitz, et.al., 1979). Yozawitz and Bruder (1978) investigated the laterality of patients with affective disorder on a click detection task and found decreased right hemisphere performance, similar to that of individuals with right hemisphere lesions. Johnson and Crockett (1982), presented different musical chords simultaneously to the two ears and required subjects to identify the two chords from a subsequent series of four binaurally presented chords. The unipolar depressed subjects in the study failed to show a left ear advantage when ill, but showed normal ear asymmetry when their depression was in remission. In a study of the effects of treatment on hemispheric functioning, Strauss, Moscovitch, and Olds (1979) investigated the performance of depressed adults on dichotically presented speech sounds before and after right unilateral electroconvulsive shock

(ECT) to the frontotemporal regions. While right ear superiority was lacking prior to shock, a normal pattern was observed following treatment. In a review of dichotic listening studies spanning the years 1970 through 1987 focusing on psychiatric patients, Bruder (1988) concluded that patients having affective disorders failed to show a left ear advantage for a variety of nonverbal tasks including dichotic click detection, dichotic chords, and the complex tone test. However, asymmetry returned to normal when the depression cleared.

Unfortunately, very few investigators have used both verbal and nonverbal dichotic listening tasks in the same study, allowing for comparison of laterality for word and affect within subjects. Bryden and Macrae (1989) developed a dichotic listening procedure which demonstrated that left hemisphere verbal superiority and right hemisphere nonverbal superiority could be obtained using the same stimuli. These investigators presented four words, spoken in four different affective tones of voice, paired dichotically. Normal subjects were significantly more accurate at the right ear when the target was a word, and significantly more accurate at the left ear when the target was an affect.

Prosody/right hemisphere dysfunction studies.

Right hemisphere dysfunction has been related to deficits in all aspects of nonverbal communication,

including perception of both affective and nonaffective intonation (Tompkins & Mateer, 1985; Heilman, Bowers, Speedie, & Coslett, 1984), comprehension of nonverbal humor (Gardner, Ling, Flamm, & Silverman, 1975), understanding of facial expression (Buck & Duffy 1980; Sackheim, et al., 1978), and the ability to match pictures of affective facial expressions with the appropriate affective description (Borod, Koff, & Caron, 1983; Bowers, Bauer, Coslett, & Heilman, 1985; Cicone, Wapner & Gardner, 1980; DeKosky, Heilman, Bowers, & Valenstein, 1980; Escoff, 1984; Kolb & Taylor, 1981).

Observation of the anomalous affect of brain injured patients with lateralized lesions has led to a significant body of literature devoted to the investigation of prosody. The term was first used by Monrad-Krohn (1947), to refer to the nonverbal elements of speech, including pitch, tempo, stress, and inflection, which convey shades of meaning. In an early study of the effects of specific brain lesions on nonverbal comprehension, Heilman, et al. (1975) presented semantically neutral sentences spoken in happy, sad, angry or indifferent tones of voice to patients with right or left hemisphere lesions, requesting them to identify the affective tone. Performance of right hemisphere patients was significantly poorer than that of left hemisphere patients. These investigators concluded that posterior lesions of the

right hemisphere disrupted patients' ability to detect nonverbal affect in speech. Subsequently, Tucker, et al. (1976) asked patients to indicate whether the affective tone of one sentence matched or was different from a second affective sentence. The same patients were then requested to identify the affective tone (happy, sad, angry, neutral) in which semantically neutral sentences were spoken. Right hemisphere patients performed significantly less accurately than left hemisphere patients, across both conditions.

In a subsequent study of expressive prosody, Tucker, et al. (1976) found that anterior right hemisphere lesions impaired patients' abilities to express affect through tone of voice. Ross and Mesulam (1979) subsequently described two case studies of children with documented lesions to the right fronto-parietal region, which resulted in the loss of both gestural ability and affective prosody in their speech. Noting that subjects with these deficits appeared to have flat affect, Ross and Mesulam proposed that gesturing and affective prosody were functions of the right hemisphere, with an organization similar to that of propositional speech in the left hemisphere. These investigators theorized that the right posterior region was activated in the processing of receptive prosody, and the right anterior region was activated in the expression of affect.

In an effort to study both prosodic and propositional

elements of speech in the same study, Heilman, et al. (1984) filtered simple sentences so that subjects received no semantic message. Patients were assigned to one of three groups by status; a) those with right hemisphere lesions, b) those with left hemisphere lesions, or c) normal controls. In one condition, subjects heard emotional prosody spoken in happy, sad, angry, and neutral tones of voice. In a second condition, they heard nonemotional prosody (statements, questions, or commands). The right hemisphere group showed decreased comprehension of both emotional and nonemotional prosody, as compared to the left hemisphere and normal groups. This finding supports the importance of a fully functioning right hemisphere in the decoding of nonsemantic elements of speech.

There is relatively little data on the effects of right hemisphere dysfunction on prosody in children. However, several investigators have noted that children with documented neurological deficits of the right hemisphere exhibit corresponding deficits in expressive and receptive prosody. Bell, Davis, Morgan-Fisher, and Ross (1990) presented two case studies of children with documented right hemisphere lesions, who exhibited deficient receptive and/or expressive affective prosody which became less severe as the lesions resolved. Additionally, Deonna, Chevrie, and Hornung (1987) reported a case study involving a 7 1/2 year old boy

suffering from partial complex seizures originating in the nondominant hemisphere (left hemisphere in this case). At the most severe point in his illness, spontaneous speech was noted to be monotonic and arrhythmic. The child also could say the words of well-known songs, but could not sing with a recognizable melody. Subsequent to treatment with carbamazapine, the boy's speech regained normal fluency and intonation. Similarly, Cohen, Prather, Town and Hynd (1990) investigated neurodevelopmental differences in affective prosody in children with left or right temporal lobe epilepsy, as well as a normal control group. Right temporal lobe epileptics were significantly less accurate than normal controls on the comprehension of affective prosody, and on the comprehension of simultaneous affective prosody and emotional gestures.

Studies of the performance of depressed individuals on measures of prosodic reception and expression are presently lacking. The only existing data which suggests a possible relationship between depression and dysfunction in receptive or expressive prosody, originates from research on a syndrome referred to as "nonverbal learning disability" or NVLD (Tranel, Hall, Olson, & Tranel, 1987; Weintraub & Mesulam, 1983). Children with NVLD exhibit difficulty with various aspects of right posterior functioning, in addition to organization and self-regulation deficits associated with

frontal executive functioning. Palombo (in press) described symptoms of nonverbal learning disability, including clinical signs of anxiety, depression, and attentional problems, problems with affective reception including poor decoding of prosodic intonation, and difficulty interpreting facial expressions and body gestures. Children with NVLD also frequently exhibit a lack of prosodic expression, including "flat" vocal intonation, diminished facial expressiveness, and few body gestures, creating the appearance of being "stiff" and restricted. Moreover, they have difficulty with visuospatial perception, organization, prioritization, and crossmodal integration, which are symptoms that are congruent with right posterior dysfunction. In addition, children with NVLD exhibit self-regulation difficulty, including poor frustration tolerance and affect modulation, difficulty adjusting to novel situations, concrete thinking, and deficiencies in concept formation, often associated with frontal functioning. Such deficits are believed to be related to early developmental abnormalities in brain function.

Nonverbal learning disability.

Several investigators (Rourke, 1987; 1988; Voeller, 1986; Weintraub & Mesulam, 1983) have measured social and emotional functioning in children with nonverbal learning disability, noting difficulty interpreting emotional and

social information. Likewise, Denckla (1978) noted that children with left-sided neurological signs also exhibited difficulty in social interaction with peers. Weintraub and Mesulam (1983) discussed a mixed sample of 14 adolescents and adults who demonstrated right hemisphere deficits, together with a pervasive disturbance in interpersonal relatedness. In a different type of study, Voeller (1986) assessed affect recognition in a group of 15 children, ranging in age from 5 to 15 years, who were referred for neurological evaluation due to behavior and learning problems. In addition to neuropsychological measures of motor, intelligence, language, and visuomotor skills, two measures of affective prosody were also administered. These measures of affective prosody consisted of the Affect Recognition Test (Hanson, 1982) and the Auditory Affect Recognition Test, (Tallman, 1984). In general, subjects demonstrated higher Verbal than Performance IQs, and scored significantly below the level expected for normal peers on both measures. However, there was a wide range of prenatal and postnatal neurological abnormalities in the sample, and the author did not specify what provisions were made to account for the wide age range of the subjects. These potential confounds increase the difficultly of drawing clear conclusions.

A relatively high correlation between child

psychiatric patients and deficits on measures of neuropsychological functioning has been noted, although patients were not specified as depressed. Tramontana, Sherrets, and Golden (1980) found that 60% of cases in a mixed sample of child and adolescent psychiatric patients without hard neurological findings demonstrated mild impairment on the Halstead-Reitan Neuropsychological Battery (HRNB). Similarly, Tramontana & Sherrets (1985) found that at least 50% of a sample of preadolescent boys with chronic psychiatric histories, for which brain damage had been ruled out by CT scan, exhibited neuropsychological abnormality based on scores on the HRNB, or the Children's revision of the Luria-Nebraska Neuropsychological Battery. Impaired performance did not appear to be associated with full-scale IQ.

Other researchers (e.g., Weintraub & Mesulam, 1983) have postulated a possible relation between some forms of depression and right hemisphere involvement. Kaslow, Rehm, and Siegel (1984) found that higher scores on the Children's Depression Inventory (CDI) were associated with poorer performance on the Wechsler Intelligence Scale for Children-Revised (WISC-R) subtests of Block Design, Coding, and Digit Span. Blumberg and Izard (1985) found a similar pattern of response between the Peabody Picture Vocabulary Test (PPVT) and the Block Design subtest (WISC-R), using the CDI as the

index of depression.

Several studies have reported improved performance on neuropsychological measures of right hemisphere and/or frontal lobe functioning following treatment with antidepressives (Brumback, Staton, & Wilson, 1980; Staton, Wilson & Brumback, 1981; Wilson & Staton, 1984). Staton et al. (1981) found that improvement in depressive symptoms was also associated with improved performance on the WISC-R subtests of Similarities, Comprehension, Block Design and Coding, as well as on the Children's Category Test of the Halstead-Reitan Neuropsychological Battery for Children, the Matching Familiar Figures Test, and the Visual Reception Test of the Illinois Test of Psycholinguistic Abilities, all measures which tap frontal or right posterior functioning. Sackheim, Decina, and Malitz (1982) reviewed much of the literature pertaining to functional brain asymmetry and affective disorders, and concluded that affective disorders, particularly unipolar depression, tend to be associated with right hemisphere cognitive dysfunction.

While studies linking deficits in prosodic reception and expression with depression are presently lacking, a number of investigators have measured the performance of depressed adults on measures of neuropsychological functioning. Flor-Henry (1983) reviewed a number of studies which compared depressed, manic, and schizophrenic subjects,

and concluded that depression without mania was specifically related to decrements in visual perceptual accuracy. Kushnir, Gordon, and Heifetz (1980) designed a "cognitive laterality" battery which included right posterior functions of visual localization, orientation, form comprehension, and touching cubes. When depressed patients were assessed using the battery, 9 of the 11 patients demonstrated impairment of these functions compared to measures of left hemisphere functioning.

There are few studies relating to the effects of depression on neuropsychological functioning in children. McAuslin (1975) noted an increased frequency of neurologically soft signs in depressed children. Additionally, Shaffer, et al. (1985) observed that psychiatric disorders characterized by anxiety, withdrawal, and/or depression occurred more frequently in adolescents who demonstrated early soft signs. Few studies, however, have explored the cognitive correlates of depression in children. In a recent bibliography of over 100 articles relating to childhood depression (Petti, 1989) included only one study which investigated the cognitive correlates of depression. Similarly, in a review of 145 neuropsychological studies relating to depressive disorders (Newman & Sweet, 1992) only one study focused on the neuropsychology of depression in children. Existing data has suggested

relatively greater dysfunction in nonverbal, novel problem solving skills, compared to verbal skills, as measured by lower scores on the WISC-R Block Design and Coding subtests, (Kaslow, et al., 1984; Blumberg & Izard, 1985). Other investigators (Brumback, et al., 1980; Staton, et al., 1981; Wilson & Staton, 1984) found that when depressed children were measured before and after treatment with antidepressant medication, performance improved on measures of right posterior and left frontal functioning (e.g., WISC-III Block Design & Coding subtests; the Category Test of the Halstead Reitan Neuropsychological Battery). Moreover, Staton et al. (1981) noted improvement in two boys who exhibited mild left-sided hemiparesis prior to antidepressant therapy. Additionally, several studies have investigated the performance of depressed individuals on neuropsychological measures of lateralized function, before and after ECT therapy. Kronfol, Hamsher, Digre, and Waziri (1978) measured performance on neuropsychological tests before and after ECT, to either the right or left hemisphere. The results indicated decreased right posterior functioning, in relationship to left posterior functioning. Following eight administrations of ECT to the right hemisphere, those patients' performance was significantly improved on measures of constructional praxis and judgement of line orientation, both of which are posterior right hemisphere functions.

Further, these patients perceived themselves as less depressed on a self-rating depression scale. In contrast, there was no significant improvement on left hemisphere functioning when depressed patients received either left or right hemisphere ECT. The authors concluded that the improvement reflected alleviation of the depression, and that "depression itself interferes with cognitive functions, mainly those subserved by the nondominant hemisphere" (p. 565). Goldstein, Filskov, Weaver, and Ives (1977) assessed patients with a diagnosis of unipolar depression, before and after ECT, using the Halstead-Reitan Neuropsychological Battery. These investigators found evidence of right hemisphere dysfunction prior to ECT. However, when ECT alleviated the depression, performance on measures of right hemisphere functioning improved as well.

Specific studies of the relationship between cortical function and qualified and quantified child depression are required before the relationships between depression and other childhood dysfunction can begin to be elucidated.

Diagnosis: Depression with Anxiety

Clinical observation has noted that depression and anxiety are frequently comorbid in children (e.g., Puig-Antich & Rabinovich, 1986; Puig-Antich, Blau, Marx, Greenhill, & Chambers, 1978), as well as adults (Akiskal, 1985; Ayd, 1984; Breier, Charney, & Heninger, 1984; Foa &

Foa, 1982). In a comprehensive review of adult neuropsychological studies performed on depressed subjects, Everhard (1996) concluded that most had involved individuals who were both anxious and depressed. Researchers have also noted a relationship between anxiety and depression in children. In a longitudinal study of depressed children using subtypes from the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM-III, APA, 1987), Kovacs, Feinberg, Crouse-Novak, Paulauskas, & Finkelstein (1984) found a very high frequency of psychiatric disorders which were comorbid with depression, including anxiety disorders. The children in this sample were classified as having major depression, with 33% also having a concurrent anxiety disorder. Similarly, 36% of cases had a dysthymic disorder with a concurrent anxiety disorder. Other investigators have noted comorbid anxiety and depression in prepubertal children, as well. Kovacs, Gatsonis, Paulauskas, and Richards (1989) investigated the presence of anxiety in a sample of 104 depressed outpatient children, 8 to 13 years of age, and found that 39 (31.5%) had comorbid anxiety. Other investigators (e.g., Cytryn & McKnew, 1972; Foa & Foa, 1982; Frommer, 1968; Gittleman, Klein & Klein, 1973; Glaser, 1968; Puig-Antich, et al., 1978) have reported similar findings. Additionally, depression with anxiety has been found in the general child population (Anderson,

Williams, McGee & Silva, 1987; Costello, et al., 1988).

Further, researchers studying anxiety have noted comorbid depression. Tisher (1983) assessed anxiety and depression in a group of children with significant school attendance difficulties, as compared to a group of regularly attending students. Based on child and parent reports, those children with difficulties in attendance demonstrated higher levels of both anxiety and depression than those who attended regularly. Bernstein and Garfinkel (1986) observed that 50% of their sample, consisting of 26 children with school phobia, had a concurrent DSM-III diagnosis of affective disorder. Children diagnosed with an affective disorder were most symptomatic, regardless of whether or not they also had an anxiety disorder. Those with both anxiety and affective disorder, however, were more similar to children with only affective disorder than to those children with only anxiety disorder. While the authors acknowledged difficulty determining which disorder was primary in children with a dual diagnosis, depressed children appeared more likely to report anxiety than anxious children were to report depression, suggesting that depression was the primary disorder. Other studies (Foa & Foa, 1982; Hershberg, Carlson, Cantwell, & Strober, 1982) cite similar findings.

The comorbidity of anxiety with depression was noted in clinical observations of adults as early as the time of

Hippocrates, (cited in Lloyd, 1983), who described "a woman (who) suffered from insomnia, loss of appetite...complained of fears and talked much...(and) showed despondency". However, there has been little agreement as to the relationship, or lack thereof, between the constructs. Freud (1894) argued for the separation of anxiety neurosis from neurasthenia.

The idea that anxiety and depression represent different affective states is intuitively appealing, as well as being supported by theory. For example, in his Theory of Differential Emotions (Izard, 1972, 1977), Izard argued that fear is the dominant emotion in anxiety, while sadness is focal to depression. Thus, this author proposed a clear differentiation between anxiety and depression at the basic emotional level. While the view that anxiety and depression represent two separate entities which overlap is more widely held (e.g., Brady & Kendall, 1992), a number of investigators have argued that the two disorders are better conceptualized as part of a larger construct, which has been referred to as "general psychological distress" or "neuroticism", reflective of the substantial overlap between symptoms. Watson and Clark (1984) described this as "negative affectivity".

Thus, both clinical observation and research support that anxiety and depression do exist concurrently in at

least a subsample of the population, and that this is particularly true in children. While children have been identified for participation in the present study based on research criteria (cut-off scores on specific measures of anxiety and depression) the predictive validity of these measures is reflective of the clinical criteria set forth in DSM-III-R, with the Child Depression Inventory generally measuring symptom areas of Major Depression, and the Spielberger State Trait Anxiety Inventory for Children similarly measuring symptom areas of Overanxious Disorder. The DSM-IV (APA, 1994) however, continues to include anxiety and depression under two separate diagnostic categories, thus the diagnostic criteria for each will be reviewed separately.

Depression: Clinical criteria.

The DSM-IV (APA, 1994) lists criteria required for a clinical diagnosis of Major Depressive Episode in adults, with minor modifications for children. These criteria include depressed mood (which can be demonstrated by irritability in children or adolescents), markedly diminished interest or pleasure in activities, significant weight loss or gain (or failure to make expected weight gains), insomnia or hypersomnia, psychomotor agitation or retardation, fatigue or loss of energy, feelings of worthlessness or excessive or inappropriate guilt,

diminished ability to think or concentrate, and indecisiveness. Diagnosis requires the nearly daily presence of a minimum of 5 of the above symptoms during the same 2-week period, with at least one of the symptoms being either depressed mood, or loss of interest or pleasure. Children who fail to meet the full criteria may qualify for a diagnosis of Dysthymic Disorder (or minor depression) if a depressed or irritable mood is present for at least 10 months of the most recent 12 month period, in conjunction with at least two other symptoms (similar to those above). With minor modifications, the criteria set forth in DSM-IV are identical to those in the earlier DSM-III (APA, 1987).

The above criteria are based on the presumption that depression in children presents similarly to that of adults, and are adapted from the criteria for adult depression published by Feighner, Robbins, Guze, Woodruff, Winokur, and Munoz (1972). Some investigators have argued for modified criteria for children, although most tap similar domains as those of DSM-IV. Petti (1989) observed that in preadolescent children, symptoms of dysphoric mood may be accompanied by hyperactivity, irritability, somatic complaints such as abdominal pain, difficulty with school and/or significant school attendance difficulties, and self-deprecatory ideation with or without morbid or suicidal content.

Weinberg, Rutman, Sullivan, Penick, and Deitz (1973)

studied depression in prepubertal children who were identified for the study based on symptoms modified from the Feighner, et al (1972) criteria. Based on their clinical experience, these investigators included both dysphoric mood, and self-deprecatory ideation in the essential criteria, together with two or more of the following: aggressive behavior (agitation), sleep disturbance, a change in school performance, diminished socialization, change in attitude toward school, somatic complaints, loss of usual energy, and an unusual change in appetite and/or weight. Most of these symptoms overlap the DSM-IV (APA, 1994) criteria.

Carlson and Cantwell (1982) compared groups of children diagnosed according to DSM-III (APA, 1987) criteria with children diagnosed according to Weinberg criteria. These investigators found that while there was overlap between the groups, Weinberg's criteria identified more children as depressed than the more restrictive DSM-III criteria. Children who qualified as depressed according to both criteria were significantly more depressed on the Children's Depression Inventory (Kovacs & Beck, 1977), than those meeting only the Weinberg criteria.

Overall, it would seem that there is general clinical agreement on the premise that many symptoms of depression displayed by children are similar to those displayed by

adults. There is somewhat less agreement on the number or severity of symptoms by which to clinically diagnose depression in children. Ultimately, the value of differential classification relates to research and/or treatment outcomes. More research and/or treatment studies are needed to further inform the differentiation of subtypes. Until such time, the clinical criteria set forth in DSM-IV continues to be widely used in the diagnosis of depressed and anxious children.

Depression: Research criteria.

Research diagnostic criteria have differed widely, across studies, suggesting that independent inquiries may identify diverse groups of children (e.g., Carlson & Cantwell, 1981; Kazdin, 1989). This problem has made questionable the generalizability of findings to children outside of a particular study or diagnostic method. Most frequently in research, children have been identified as depressed if they meet predetermined "cut-off" scores, or if their score is extreme on an inventory or questionnaire designed to measure the severity of depressive symptoms.

The most common means of operationalizing depression and identifying depressed children for research is based on questionnaire measures with either the child or the parent reporting. The most frequently used child report measures have been the Child Depression Inventory (CDI; Kovacs,

1981), the Children's Depression Scale (CDS; Lang & Tisher, 1978), and the Child Behavior Checklist (CBCL-YSR; Achenbach & Edelbrock, 1987). Parent report measures have included the CBCL-PRF (Achenbach & Edelbrock, 1983), the Personality Inventory for Children (PIC; Wirt, Lachar, Klinedinst, & Seat, 1977), the Connors Parent Questionnaire; Connors, 1973), and the Revised Behavior Problem Checklist (RBPC; Quay & Peterson, 1983). Two studies (Asarnow & Carlson, 1985; Lobovits & Handal, 1985) found that scores on child report depression scales (CDI, Depression Self-Rating Scale) accurately identified one-half to three-fourths of children diagnosed with depression.

Interestingly, child and parent reports using the same scale are frequently poorly correlated. Kazdin, Colbus, and Rogers (1986) investigated responses of children and their mothers on the CDI, the CDS, the Belleview Index of Depression (Petti, 1978), and the Depression Symptom Checklist (DSCL; Kazdin, et al., 1986). A major finding was that children consistently rated their depression as less severe than their parent's rating, indicating that identification of true positives required different cut-off scores for parents' versus children's report. Additionally, these investigators found that while accuracy of identification was improved (> 80%) when multiple measures from both parent and child were combined in a discriminant

analysis, the use of multiple measures from one source (e.g., only the child) did not substantially increase classification accuracy from what was achieved using optimal cutoffs from individual depression scales.

Anxiety: Clinical Criteria.

The DSM-IV (APA, 1994) lists anxiety disorders separately from affective disorders. Diagnostic criteria of Generalized Anxiety Disorder (which includes Overanxious Disorder of Childhood) encompass essential features of excessive anxiety and worry which are difficult to control, concerning a number of events or activities (such as work or school performance) occurring more days than not, for at least 6 months. Additionally, at least one of the following symptoms must be present to make the diagnosis in children: a) restlessness or feeling keyed up or on edge, b) being easily fatigued, c) difficulty concentrating, d) irritability, e) muscle tension, and/or f) sleep disturbance (difficulty falling or staying asleep). In children or adolescents, anxieties and worries often concern the quality of their performance or competence at school or in sporting events. Last (1989) notes that three hallmark symptoms of Overanxious Disorder are worrying, overconcern about competence, and marked self-consciousness. It is evident from comparing the above criteria for anxiety with those for depression, that a considerable amount of overlap exists

even within the DSM guidelines.

Similar to the documentation of depression in children, a significant number of clinical studies of childhood anxiety has emerged only since the 1980's. Such studies have followed symptom criteria set forth in DSM-III. Potential symptom differentiation due to developmental differences has generally not been explored. Investigators (e.g., Last, 1989) suggest that approximately one-third of children with Overanxious Disorder also meet the DSM-III criteria for Major Depression.

The best known of the various clinical syndrome rating scales (which sum ratings of various aspects of the disorder to produce an overall index of severity) is the Hamilton Rating Scales for Anxiety (HRSA: Hamilton, 1959). Diagnostic studies of anxiety in adults over the past 15 years have frequently identified subjects by means of DSM-III (APA, 1994) criteria, or by the Research Diagnostic Criteria (RDC) (Spitzer, Endicott, & Robins, 1978) generated by the Schedule for Affective Disorders and Schizophrenia-Lifetime Version (SADS-L: Endicott & Spitzer, 1978), a semistructured clinical interview which yields diagnoses and subtypes of affective disorders and schizophrenia. Coverage of anxiety with this instrument, however, is somewhat limited (Clark, 1989). More recently used have been the Structured Clinical Interview for DSM-III (SCID; Spitzer &

Williams, 1983), the Diagnostic Interview Schedule (DIS; Robins, Helzer, Croughan, & Ratcliff, 1981), and the Anxiety Diagnostic Interview Schedule (ADIS; DiNardo, O'Brien, Barlow, Waddell, & Blanchard, 1983). Published reviews and reliability studies of these instruments are available (SADS; Matarazzo, 1983; DIS: Breslau & Davis, 1985; Hesselbrock, Stabenau, Hesselbrock, Mirken, & Meyer, 1982). Tuma and Maser (1985) observed that the assessment of anxiety is enormously complex, having emerged from the widely adopted three-systems definition of the anxiety response formulated by Lang (1964, 1968, 1978). This conceptualization includes verbal report of the experience of anxiety (e.g., fear, dread, panic, worry, obsession, guilt, inability to concentrate), avoidance behavior towards the perceived threat, and patterns of visceral and somatic activation. Tuma and Maser (1985) argued that these systems interact with varied degrees of synchronization, such that it is inadequate to measure only one system in the identification of anxiety disorders. Similarly, Weissman (1985) observed that semantic ambiguity, difficulties separating anxiety states from traits, and heterogeneity of expression "create an epidemiologic nightmare" (pg. 275). Obviously, detailed exploration of these issues is beyond the scope of the present study and the interested reader is referred to A. Tuma & J. Maser, Anxiety and the Anxiety

Disorders (1985), for a comprehensive collection of articles, together with the references cited above.

Anxiety: Research criteria.

A number of self-report questionnaires have been developed to assess anxiety in adults for research purposes, including the Taylor Manifest Anxiety Scale (TMAS: Taylor, 1953), which consists of 50 true-false statements taken from the Minnesota Multiphasic Personality Inventory (MMPI: Hathaway & McKinley, 1942) the Zung Self-Rating Anxiety Scale (Zung, 1971) based largely on DSM-II criteria for anxiety disorder, and the State-Trait Anxiety Inventory (STAI: Spielberger, Gorsuch & Lushene, 1970). The STAI is composed of two 20-item self-report measures designed to assess state and trait anxiety separately, in samples of normal individuals. Individual items are scored on a 4-point Likert scale, ranging from "almost never" to "almost always". Both measures have demonstrated high internal consistency, and the trait form has maintained good test-retest reliability for intervals up to 3 months (Spielberger, et al., 1970).

Relatively fewer self-report measures of anxiety have been developed to assess children. One of the most frequently used is the State-Trait Anxiety Inventory for Children (Spielberger, Edwards, Lushene, Montuori & Platzek, 1973) which was modeled after the adult version and was

developed as a research tool for the investigation of consciously perceived feelings of apprehension, tension, and worry in elementary school children. The scale was intended as a practical screening device to assess children's anxiety, and to monitor it during treatment. While data support reliability and construct validity, studies of discriminate validity indicate a high correlation between the Trait scale of the STAIC and the CDI (Saylor, Finch, Spirito, & Bennett, 1984) suggesting that both scales may be measuring a broader construct of negative feelings in children.

Prevalence

Estimates of the prevalence of depression and anxiety in children vary from study to study, reflecting the variability in classification previously discussed. Conservative estimates place prevalence at approximately 5.2% of the childhood population (Lefkowitz & Tessiny, 1985). However, other studies estimate that depression may affect up to 33% of children, depending on how it is defined and assessed. Albert and Beck (1975) found that 36% of elementary school boys enrolled in a suburban parochial school met criteria for depression. In the Isle of Wight study of 10 to 11 year old boys (Rutter, Tizard, & Whitmore, 1981) 13% were categorized as depressed through interviews, 9% appeared preoccupied with depressive topics, and 15%

showed poor emotional responsiveness. Parent and teacher questionnaires described approximately 12% of this sample as very miserable. Reassessment of the same children at age 14-15 (Rutter, et al., 1981) found that over 40% reported substantial feelings of sadness and depression at interview, and 20% expressed feelings of self-deprecation. Rutter (1986) found a strong association between depression and puberty in the older children, with scores in the intermediate range on all measures. Regardless of the exactness of these estimates, they suggest that there are a substantial number of children who potentially function at less than optimal levels due to some degree of generalized emotional distress. None of the above studies included estimates of comorbid anxiety.

Frequency

A number of adult studies have identified depression as the most frequently occurring emotional disorder among psychiatric patients (e.g., Lipkin, 1985; Weissman & Boyd, 1985). Additionally, depression has been recognized in adult patients with concurrent medical illness (e.g., Tarter, Van Thiel, & Edwards, 1988) and neurological disorders such as Parkinson's disease (see Mayeux, 1983 for a comprehensive review; also Strub & Black, 1981) Multiple Sclerosis (Baretz & Stephenson, 1981; Peyser & Poser, 1986; Schiffer, Caine, Bamford, & Levy, 1983) brain trauma (McMordie, 1988; Varney,

Martzke, & Roberts, 1987) and stroke (Robinson, Starr, Kubos, & Price, 1983). The presence of depression in children has been noted concurrently with medical and neurological disorders, including G.I. disorders, diabetes, hyperthyroidism, epilepsy, and organic brain syndrome (Boswell, Lewis, Freeman, & Clark, 1967). Further, depression and anxiety are frequently associated with Attention Deficit Hyperactivity Disorder (ADHD), and various types of Learning Disability (Cullinan, Epstein, & Lloyd, 1981; Rosenthal, 1973).

Chapter III

Purpose of the Investigation

Objectives

Review of existing adult literature focused on adults with lateralized brain lesions, or those who are depressed, suggests that dysfunction related to depression may follow a specific pattern of hemispheric activation. Tucker, et al. (1981) suggested that frontal activity of the right hemisphere represented an inhibitory function which suppressed information processing (right temporoparietal). Another model proposes a pattern of decreased right posterior activation, relative to left, and increased right frontal activation, relative to right (e.g., Heller, 1990; Tucker, 1993). To date, such a model has not been [predictively] tested. Therefore, the purposes of this study were several. First, it was proposed to investigate the functional correlates of moderate to high levels of depression with comorbid anxiety on children's cerebral functioning. Second, it was proposed to focus the study on a population of boys in a suburban elementary school who were classified as normal students, without learning disabilities, attention deficit disorder, or previously identified anxiety or depression. Further, the group of anxious-depressed subjects included a significant number of boys who were not "clinically" depressed on the CDI as

defined by Kovacs (1981). Third, the neurobehavioral measures used for the study were specifically chosen to evaluate functional systems of the right and left frontal regions and the right posterior region of the cerebrum. These included auditory perception of affective and propositional speech, lateralized perception of affect versus word, measured by accuracy of dichotic processing, lateralized motor output measured by grip strength, and measures of frontal activation including verbal fluency, sequencing and alternation, and problem solving.

Two groups of boys were compared. One group was comprised of boys, ages 9 to 11 years, who self-reported moderate to high levels of depression, concurrent with similar levels of anxiety. A second group was comprised of boys of the same ages who reported low levels of both depression and anxiety. None of the boys were in therapy for depression or were previously identified as depressed. The study advanced the following major hypotheses:

1) Nine to eleven year-old boys with moderate to high levels of anxiety and depression (anxious-depressed), compared to controls with low levels of anxiety and depression (non-anxious, non-depressed), were predicted to exhibit less accurate performance in the decoding of affective prosody.

2) On a dichotic listening task, it was predicted

that all subjects would demonstrate more accurate perception of affect presented to the left ear, as compared with presentation to the right ear. Conversely, more accurate perception of words presented to the right ear was predicted, compared with presentation to the left ear. Further, the anxious-depressed boys were expected to demonstrate a less lateralized pattern of response on dichotic listening. While the direction of specific alteration in functioning has not been consistent in the literature, it was hypothesized that such alteration would most likely reflect decreased right hemisphere functioning, including decreased left ear performance by the anxious-depressed subjects on a dichotic listening task.

3) Boys who were anxious-depressed were also expected to demonstrate relatively less grip strength overall, when compared to non-anxious, non-depressed individuals. Further, they were expected to exhibit more perseveration, and greater fatigue than non-anxious, non-depressed subjects. Finally, anxious-depressed boys were predicted to be less lateralized to the left hemisphere (right hand).

4) Boys in the same sample were also predicted to demonstrate significantly poorer performance on neuropsychological measures of frontal function, including verbal fluency, sequencing and alternation and problem-solving (concept formation). The predicted outcomes were

based on similar findings in adult research on depressives as compared to normals, and/or expected dysfunction of right posterior/left frontal systems.

Chapter 4

Method

Subjects

Thirty-eight boys, ages 9 to 11 (108 to 132 months) enrolled in grades four and five of a suburban Chicago public school were selected to participate in the present investigation, from a larger group of boys, based on their scores on the Child Depression Inventory (CDI: Kovacs & Beck, 1977) and the Trait subscale of the State-Trait Anxiety Inventory for Children (STAIC: Spielberger, et al., 1973). The criteria for establishing cut-off scores for these groups is discussed in the "Apparatus" section of this paper. Nineteen children who scored at or above 12 on the CDI (mean = 18.26, S.D. = 5.98) and at or above 34 on the STAIC (mean = 40.21, S.D. = 4.48) were assigned to a anxious-depressed group. Within this group, thirteen boys were moderately depressed, with scores ranging from 12 to 18 (below the clinical cut-off score of 19 established by Kovacs 1981). The other six boys were highly depressed, with scores ranging from 20 to 32. Nineteen children who scored at or below 5 on the CDI (mean = 2.95, S.D. = 1.96) and at or below 24 on the STAIC (mean = 28.42, S.D. = 2.65) were assigned to a nonanxious-nondepressed control group. Within this group, scores ranged from 5 to 0.

It was initially proposed to include two additional

groups of boys in this study, one of which would display high anxiety and low depression ("pure" anxiety) and the other of which would display high depression and low anxiety ("pure" depression). Based on a total screening population of 65 boys there were inadequate numbers of these children to fill either group. There may be several reasons for this finding. First, a significantly larger sample may be required to identify children who exhibit only anxiety or depression. Second, such children may not be found within a nonclinical population. Third, the measures of anxiety and depression utilized in this study may not adequately differentiate depression from anxiety. A number of authors have commented on the overlap of item content between the two measures (Norvell, Brophy, & Finch, 1985; Saylor, et al., 1984; Shoemaker, 1987) although they remain the most frequently used indicators of anxiety and depression in research. In an extensive review of adult studies of anxiety and depression (Everhart, 1996) the author concluded that most neuropsychological studies of depression were developed on populations with comorbid anxiety, suggesting that other researchers have encountered similar problems with differentiation. Watson and Clark (1984) argued convincingly that children, themselves, poorly differentiate feelings of anxiety from those of depression, and conceptualized "negative affectivity", a constellation of symptoms which

includes elements of both anxiety and depression, as being more descriptive of children's true affective experience.

In addition to the above grouping procedures, boys had to be right hand dominant, with normal hearing and normal corrected or uncorrected vision (as determined by school screening). Lateral dominance was determined by scores on the Lateral Preference test (Coren, Porac, & Duncan, 1979). Additionally, all subjects had normal intelligence (80 to 120), as determined by a standardized intelligence test such as the Wechsler Intelligence Scale for Children - Third Edition (Wechsler, 1991) and were placed within a normal classroom setting.

Boys who were identified as having learning disabilities, Attention Deficit Hyperactivity Disorder, or psychiatric disturbance (other than anxiety and depression, qualified within this study) were excluded. The study was designed to conform to the guidelines and procedures for research with human subjects, and was approved by the Human Subjects Committee and Institutional Review Board of Virginia Polytechnic Institute and State University, as well as the Institutional Review Board of the University of Chicago. All subjects and their parents provided informed consent prior to participation.

Procedures

General testing procedure.

Pretesting for selection to groups was carried out in a general classroom setting during the school day. Boys selected to participate in one of the two groups were further tested individually at their school, within a two-week period of administration of the screening measures. All further testing measures were administered to subjects individually, in a quiet room, removed from any interference from school activities. Each subject completed the Lateral Preference Test to establish handedness, and only right hand dominant boys were accepted for the study. Standardized administration procedures were followed for each test. In all cases, the experimenter administering the tests was unaware of the group to which each subject was assigned.

Apparatus: Pretesting for Assignment to Groups

Child Depression Inventory.

The CDI (Kovacs & Beck, 1977) is a 27-item self report inventory which was designed to measure depression in children, and addresses symptoms of depression set forth in accordance with the DSM-III criteria for major depression. It has been employed in a large number of studies measuring cognitive, behavioral, and neurovegetative signs of depression in elementary and high school children. The inventory employs statements which are arranged in increasing and decreasing order of intensity of response. For example:

"I am sad once in a while."

"I am sad many times."

"I am sad all the time."

Each question is scored from 0 to 2 points, with the least favorable response earning the most points. Individual scores are compared to normative measures to derive an index of the degree of individual depression. While the cut-off score for identifying clinically severe depression in children was initially established at 19 or above by Kovacs (1981) this score typically identifies the upper 10% of a sample as clinically depressed. A number of investigators have supported the use of a less stringent cutting score for research purposes. Kazdin, et al. (1986) studied accuracy of classification of depression in a sample of 170 psychiatric inpatients, ranging from 7 to 13 years of age. Subjects scoring at or above 12 were classified as high in depression, while those below 12 were classified as low in depression. This cut-off score yielded the highest percentage of accuracy for classifying children in their sample, based on "sensitivity" (identification of true positives) and "specificity" (identification of true negatives). Overall accuracy of correct identification was approximately 60%, with similar percentages of true positives and true negatives. For comparison, the same calculation was performed using the clinical cut-off score

of 19. At that cut-off, sensitivity and specificity reached approximately 28% and 75% respectively, suggesting identification of a much lower percentage of true positives, and a somewhat higher percentage of true negatives than was achieved using the lower cut-off score. Additionally, Lobovits & Handal (1985) investigated depression in an outpatient sample of children ranging in age from 8 to 12 years. These investigators also established a cut-off score of 12 for the CDI, and were able to correctly classify 88% of the sample, with 76% sensitivity. Additionally, Asarnow and Carlson (1985) calculated an optimal cut=off score of 12 on the CDI, for an outpatient sample (ages 8-12), achieving overall classification accuracy of 71%.

The median split has also been used to discriminate high depressives from low depressives (e.g., Saylor, et al., 1984). More frequently used, however, is an upper cut-off score at the 67th percentile, and a lower cut-off score at the 33rd percentile (Bodiford, Eisenstadt, Johnson & Bradlyn, 1988; Kazdin, 1989; Seligman & Peterson, 1986). Based on previous research, children in the present study were identified as "depressed" if their score was at or above 12 (the 67th percentile for the present sample) and as "non-depressed" if their score was at or below 5 (the 33rd percentile of the present sample).

State-Trait Anxiety Inventory for Children.

Anxiety is frequently reported as a constellation of symptoms which exist comorbidly with depression. A number of authors have identified clinically high levels of anxiety in depressed samples, and considerable research supports a direct relationship between the disorders. For example, Quay (1986) used a multivariate statistical analysis to identify a single classification, "anxiety-withdrawal-dysphoria" which included both depression and anxiety disorders. Similarly, Achenbach, Connors, Quay, Verhulst, and Howell (1989) identified a single syndrome, "anxious-depressed" through a principal components analysis. Kovacs, et al. (1989) reported a comorbidity rate of 31.4% of a sample of 104 outpatients, while Strauss, Last, Herson, and Kazdin (1988) identified 28.3% of 106 child and adolescent outpatients with diagnosable anxiety and depression. For this reason, anxiety was measured concurrently with depression in the current study using the State-Trait Anxiety Inventory for Children (STAIC) (Spielberger, Edwards, Lushene, Montuori, & Platzek, 1973).

State-Trait Anxiety Inventory for Children.

The State-Trait Anxiety Inventory for Children (STAIC: Spielberger, et al., 1973) was developed as a research tool for the study of anxiety in elementary school children. It contains separate self-report scales for measuring two distinct anxiety concepts, State Anxiety (A-State scale) and

Trait Anxiety (A-Trait scale). The A-Trait scale was used in this study. It consists of 20 items that require children to report how they generally feel. It measures relatively stable individual differences in anxiety proneness, or differences between children in the tendency to experience anxiety states.

Children respond to the STAIC by selecting one of the three alternative choices for each item which describes them best. For example:

"I worry about making mistakes...

a) hardly ever

b) sometimes

c) often"

Key terms in one-half the items are indicative of the presence of anxiety (e.g., nervous, worried) while key terms in the other half of the scale reflect the absence of anxiety (e.g., calm, pleasant). For items in which the key term indicates the presence of anxiety, very and not are assigned values of 3 and 1 respectively; for items in which the key term indicates the absence of anxiety, the order is reversed with very = 1 and not = 3. Cut-off scores at or above 35 (67th percentile) were defined as high anxiety for this sample. Similarly, scores at or below 30 (33rd percentile) were defined as low anxiety for this sample.

Thus, children were classified as anxious-depressed for

this study if they scored at or above 12 on the CDI, and at or above 35 on the STAIC. In contrast, children were classified as non-anxious, non-depressed, if they scored at or below 5 on the CDI, and at or below 30 on the STAIC.

Prosody: Apparatus and Stimuli

The purpose of this procedure was to assess an individual subject's accuracy of the identification of emotional prosody in congruent and incongruent verbal statements. The stimulus tape utilized was a copy of a tape utilized by Bowers, Coslett, Bauer, Speedie and Heilman (1987). The tape consisted of 32 simple declarative sentences recorded by a female speaker in happy, sad, angry and neutral tones of voice. Eight different base sentences were used with each of the four affective intonations for a total of 32 trials. The eight base sentences included two sentences whose semantic content conveyed a happy message, two sentences whose semantic content conveyed a sad message, two sentences whose semantic content conveyed an angry message, and two sentences whose semantic content conveyed an "indifferent" or neutral message. These basic sentences were drawn from a larger pool of sentences that had been previously rated by 30 normal subjects according to the emotion conveyed by each, and also according to the intensity of this emotion as expressed on a scale of 1 to 5. The sentences used in the present study were rated as

comparable in emotional intensity across each of the four affect categories.

On 18 of the 32 trials, the emotional prosody of the sentences was congruent with the emotional message conveyed by the semantic content (e.g., "all the puppies are dead" stated in a sad tone of voice). On the remaining trials, the emotional prosody was incongruent with the emotional message conveyed by the semantic content (e.g., "all the puppies are dead" stated in a happy tone of voice"). The order of the congruent and incongruent trials was randomized on the tape, with 10 second inter-trial intervals. The stimulus tape was played on a Sony stereo recorder at a volume of 75 decibels (db).

Prosody: Procedure.

All testing was carried out individually, in a quiet room with each subject seated at a table. Subjects were told that they would hear some sentences spoken in different tones of voice, and they were then to state whether the speaker sounded like she was feeling happy, sad, angry or neutral. Subjects were specifically instructed to respond based on "how" the speaker's tone of voice sounded, rather than on "what" she stated. Subjects could respond either verbally, or by pointing to the appropriate choice on response cards placed in front of them. Each response card had a line drawing of a face that conveyed one of the four

emotional expressions, that is, happy, sad, angry or neutral. Faces were drawn in black ink on white cards. The words "happy", "sad", "angry", and "neutral" were printed under each corresponding face on the response card. Several preliminary trials were held to assure that each child understood the task. The total number of correct responses in each category, and each condition was recorded by the examiner.

Dichotic listening: Apparatus and stimuli.

The dichotic listening paradigm was designed to assess lateralized processing of prosodic and propositional speech. The procedure was adapted from that used by Bryden and MacRae (1989). The stimulus tape was a copy of that used by the same authors in an earlier dichotic listening study of affectively toned speech (Bryden, 1988). It consisted of four different two-syllable words which varied only in the stop-consonant and were spoken in different affective tones (happy, sad, angry, and neutral) paired dichotically. The stimulus set consisted of the four words, "power," "bower," "dower," and "tower," each spoken by a male speaker in happy, sad, angry and neutral tones of voice. The specific items were selected as meaningful two-syllable words in order to permit the speaker to reliably convey affect, and as words differing only in the initial stop consonant since similar material had proven to elicit a reliable right-ear

effect (Bryden, 1988). The 16 tokens were digitized on a modified PDP 11/40 computer, edited to a common length of 500 ms, equalized in loudness, and stored for playback. An initial group of 20 subjects rated each of the stimuli to ensure that the affect was perceived as intended. A dichotic tape was then produced in which each token was paired with the nine other tokens that differed in both emotional tone and phonetic content. Each trial consisted of 18 dichotically presented affective word pairs (e.g., "tower" stated in a sad tone of voice at the left ear, paired with "bower" stated in an angry tone of voice at the right ear). The individual stimulus pairs were separated by a 3 second inter-trial interval, with a 10 second break after each 18 trials. This stimulus tape was selected for use in this study because it provided a stimulus which would be meaningful, and simple enough for use with children. Also, its validity for simultaneously measuring the lateralization of affective and propositional speech had been successfully demonstrated in previous studies (e.g., Bryden & MacRae, 1988; Bryden, Free, Gagne & Groff, 1991).

Procedure.

Several modifications were made to the procedures to accommodate the population and the requirements of the present study. First, it was decided to employ a free choice paradigm, whereby children were not instructed to attend to

a particular ear, but only to a type of stimuli (affect or word). This was done because several previous studies have found priming effects in children that are difficult to reverse. For example, Kershner and Graham (1995) found that the order in which ears were monitored determined whether learning disabled children were weakly or strongly lateralized, and argued that such children might suffer from a primary attentional impairment in altering the ear advantage. Similarly, Hiscock and Chipuer (1993) studied children ages 5 to 8 years on a dichotic listening measure which required that they shift attention to the other ear following 30 trials. These investigators noted a priming effect that they concluded reflected difficulty shifting attention in either direction.

Second, it was necessary to reduce the length of the original task to accommodate children's shorter attention span. While in the original study (Bryden & MacRae, 1989) subjects received a total of 144 stimulus presentations (8 trials of 18 dichotic pairs) pilot work for the present study demonstrated that children rapidly lost attention when the task was extended beyond 72 total presentations. Since a loss of attention would be expected to affect accuracy of decoding, the task was shortened. Each subject received a total of four 18-pair trials. On two of the trials subjects were instructed to report only the affect they heard (happy,

sad, angry, neutral). On the other two trials, they were instructed to report only the word they heard (tower, power, bower, dower). This provided a total of 72 dichotic presentations, with subjects identifying the affect they heard on two trials, and identifying the word they heard on the other two trials. Presentation of the affect and word trials was counterbalanced to control for order effects. The stimulus tape was played at 75 db, through stereo earphones.

Modification of the scoring procedure was also required to adapt the stimulus tape for the present study. To control for the possibility that some affects might be more easily perceived than others, it was necessary to provide equal presentations of all four affects (happy, sad, angry, neutral) to each subject. In order to ensure that each subject's score reflected the same number of presentations, only the first 7 presentations of each affect were scored for each subject, for a total of 28 affect presentations. A similar procedure was followed for the word trials.

Subjects earned one point for each target item they correctly detected. The number of correct affective targets for each ear was summed, as well as the number of correct responses for each affect across trials. Additionally, the number of correct word targets for each ear was summed. The same procedure was followed for the subjects in both groups. Thus, asymmetry scores for this study reflect analysis of

raw data, expressed as percentage accuracy.

There is an ongoing debate of many years duration in the literature, regarding the best manner of calculating asymmetry scores. A number of authors have proposed different mathematical formulae by which to transform raw data to control for accuracy of performance. It has been argued that, potentially, differences in ear asymmetry scores could be a byproduct of differences in subject accuracy in performing the task. Bradshaw, Burden and Nettleton (1986) evaluated commonly used indices of asymmetry and concluded that they all appeared to be affected by performance level to some degree. Bruder (1988) proposed the use of absolute accuracy levels (i.e., the percentage correct for each ear) together with an index of asymmetry, pointing out that "the various indices are mathematically similar and likely to be correlated with each other, and with right minus left ear difference scores" (p. 531). His thinking was concurrent with others (Speaks, Niccum, & Carney, 1982; Wexler & Halwes, 1985). An additional problem with using asymmetry indices is the fact that they provide no data as to whether differences in asymmetry are significant. Thus the reader has no way of determining whether the "asymmetry" is meaningful or spurious without performing further analyses. In general, investigators in other areas prefer to use raw data, and

transformation is often frowned upon by statistical consultants. Statisticians argue that appropriate statistical techniques, including the use of repeated measures analyses on raw data, as opposed to transformation, use all data points, thus they are better able to capture and retain the actual profile of variability across measures. Composite measures tend to flatten variability, making it less likely that the variability which actually exists will be found (Patrey, 1995, personal communication). Further, such analysis is preferable because it reports the significance of the data, allowing the investigator to assess meaningful differences. For purposes of the present analysis, it was determined that repeated measures analyses of variance, using the raw data points, provided the clearest and most interpretable information about actual differences in the population under study.

Neuropsychological Measures

The following measures were used to assess frontal functioning. These measures were selected because they are well-known, frequently used neuropsychological tasks which are normed for children in the age range under study, and can be sensitive indicators of lateralized differences in motor and language functioning. Essentially they produce scores which indicate functional decrements of performance.

Dynamometer.

A dynamometer (DYN; Dodrill, 1978) is a device which measures grip strength. Subjects are asked to squeeze the handle of the device, one hand at a time. The results, measured as pressure or strength in kilograms (kg) are compared in this study for each of four trials, to assess relative levels of fatigue, perseveration, and laterality, by groups. This task assesses function of the motor cortex in the anterior portion of the brain (Kolb & Whishaw, 1990). For purposes of this study, relative differences in raw scores for right versus left performance will be analyzed, reflective of hemispheric dominance.

FAS Test.

Developed by Spreen and Benton (1969) this task measures spontaneous speech through the oral production of spoken words beginning with a specific letter given to the subject by the examiner. It is a frequently used measure of verbal fluency. The subject is given three trials. In each trial, the subject is instructed to say as many words as possible in one minute, beginning with a given letter. Proper names, numbers, and the same word with a different ending are not allowed. Three letters, "F", "A", and "S" are used, one for each trial. The total score is the sum of all acceptable words produced across the three one-minute trials. Existing data (e.g., Spreen & Benton, 1969) suggests that dysfunction in the anterior cortex, particularly of the

left hemisphere, results in decreased fluency.

Trail Making Test.

This test measures a subject's ability to maintain attention and to shift mental set. It also requires visual-motor tracking and motor speed (Lezak, 1983). These capabilities are associated with frontal lobe function (Stuss & Benson, 1984). The test is administered in two parts, and subjects are instructed to work as quickly as possible. First, subjects are asked to connect numbered circles in consecutive order (part A). On a subsequent worksheet, they are requested to alternate between numbered and lettered circles in sequence (part B). Each part is scored separately, and scores consist of the number of seconds required for completion. Longer completion times, as compared to norms for children, are suggestive of frontal dysfunction. Number of sequencing errors will also be scored as a measure of perseveration.

Concept Formation.

Concept Formation is a subtest of the Woodcock Johnson Tests of Cognitive Abilities (Woodcock & Johnson, 1989). This measure requires that a child conceptualize the solution to problems which increase in hierarchical complexity as the task proceeds. Problems are based on abstract rules of categorization, inclusion and exclusion, including color, shape and size. The measure yields a score

based on total number correct.

Analysis of Data

Data was analyzed to determine the significance of differences between all groups on all measures, using mixed design repeated measures analyses of variance (ANOVA). The probability of rejecting the null hypothesis and determining significance was set at $p < .05$.

Data from the prosody procedure were analyzed as follows: Differences in accuracy of identification of congruent and incongruent prosody were analyzed using ANOVA as indicated above, with the fixed factors of Group (2) and repeated measures of Congruence (2) by Affect (4).

Data from the dichotic listening procedure were analyzed as follows: Lateralization of Affect and Word by Ear was analyzed using ANOVA as indicated above, with the fixed factor of Group (2) and repeated measures of Condition (2) by Ear (2). Accuracy of identification of Affect by groups was analyzed using ANOVA with the fixed factor of Group (2) and repeated measures of Affect (4), by Ear (2).

Data from the neuropsychological measures was analyzed as follows: FAS data were analyzed to determine whether anxious depressed children were less fluent than normal children, and whether they differed in fluency, according to trials. The total number of correct words generated for each of three letters was analyzed separately

using ANOVA as indicated above, with the fixed factor of Group (2) and repeated measures of Trial (3). Scores were compared by trials and across trials.

The dynamometer task was included to assess the factors of a) grip strength, b) fatigue, c) perseveration, and d) laterality. The first performance variable, grip strength, represented the raw score for grip strength in kilograms, exerted by each hand separately, using maximum pressure. The second performance variable, fatigue, represented the raw score for grip strength in kilograms, exerted by each hand separately, for each trial. The third performance variable, perseveration, represented the raw score for half strength divided by maximum strength, for each hand separately. The fourth performance variable was the difference score, represented by mean right hand grip strength, minus mean left hand grip strength, with positive difference scores equating to lateralized right, and negative difference scores equating to lateralized left. A Group (2) x Condition (2) x Hand (2) repeated measures ANOVA was calculated for each of the above factors.

The Trail Making test yielded two performance measures. The first variable, completion time for each of two conditions (sequencing and alternation) was analyzed using a two factor ANOVA with the fixed factor of Group (2) and the repeated measure of Condition (2). The second variable,

number of errors for each condition, was analyzed using a two factor ANOVA with the fixed factor of Group (2) and the repeated measure of Condition (2).

Chapter 5

Results

Prosody

A three factor mixed design repeated measures analysis of variance was used for this analysis, with the fixed factor of Group (2) and the repeated measures of Affect (4) and Condition (2). Eight performance variables (scores on happy, sad, angry and neutral affect, nested within congruent and incongruent conditions) were analyzed. A three-way ANOVA on the variables Affect by Condition by Group revealed a main effect for Group, F (1, 36) = 11.55, $p < .001$, a main effect for Condition, F (1, 36) = 15.70, $p < .001$, and a main effect for Affect, F (3, 34) = 7.10, $p < .001$. Additionally, there was a significant Condition by Affect interaction, F (3, 34) = 2.74, $p < .029$, and a marginally insignificant Group by Affect interaction, F (3, 34) = 2.22, $p < .052$. Separate ANOVAs performed by Group for each level of Affect by Condition revealed a main effect of Group, F (1, 36) = 6.81 $p < .006$ for happy affect (see Figure 1). Non-anxious, non-depressed subjects were significantly more accurate than anxious depressed subjects on the identification of happy affect across both congruent and incongruent conditions (see Table 1).

A separate ANOVA performed as above for sad affect revealed a main effect of Group, F (1, 36) = 10.45 $p < .002$.

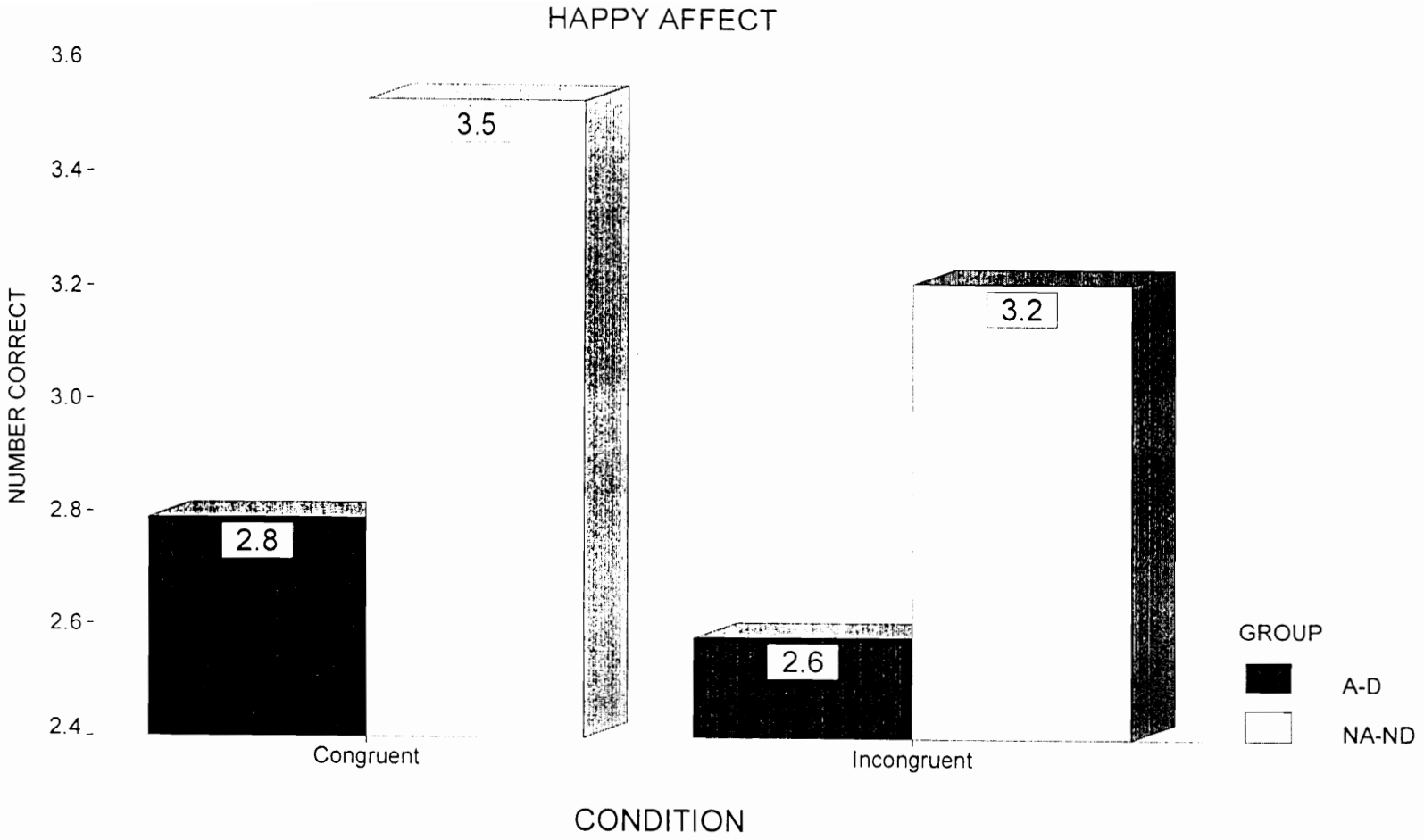


Figure 1
Accuracy of identification of happy affect within congruent and incongruent condition by subject group.

Additionally, there was a main effect for condition, F (1, 36) = 15.70 p < .001, and an interaction for Group x Condition, F (1, 36,) = 3.25 p < .040. Non-anxious, non-depressed subjects were more accurate than anxious-depressed subjects on the identification of sad affect across congruent and incongruent conditions (see Table 1). Both groups were more accurate at the identification of congruent affect than incongruent affect (see Figure 2). However, the decline in accuracy for the anxious-depressed group in the incongruent condition was greater than the decline in accuracy for the non-anxious, non-depressed group.

A separate ANOVA performed as above for angry affect revealed a main effect of Group, F (1, 36) = 5.39 p < .013. There were no other main effects, and no interactions (see Figure 3). Non-anxious, non-depressed subjects were more accurate than anxious-depressed subjects on the identification of angry affect for congruent and incongruent conditions (see Table 1).

A separate ANOVA performed as above for neutral Affect revealed a main effect for Condition, F (1, 36) = 23.65 p < .001, and an interaction on Group x Condition, F (1, 36) = 3.40 p < .037 (see Figure 4). Both groups were more accurate in the congruent than in the incongruent condition. However, non-anxious, non-depressed subjects were

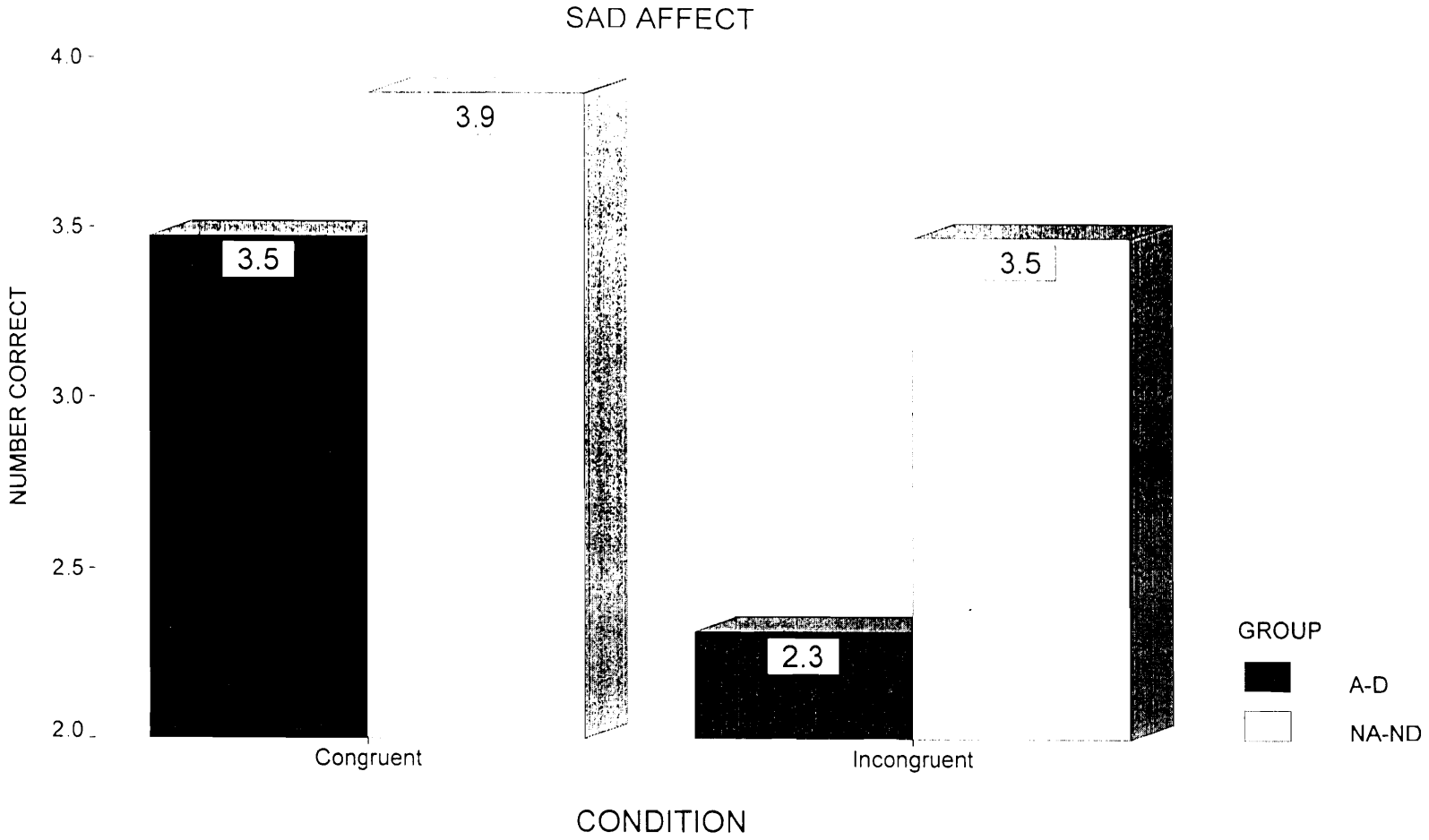


Figure 2
Accuracy of identification of sad affect within congruent and incongruent condition by subject group.

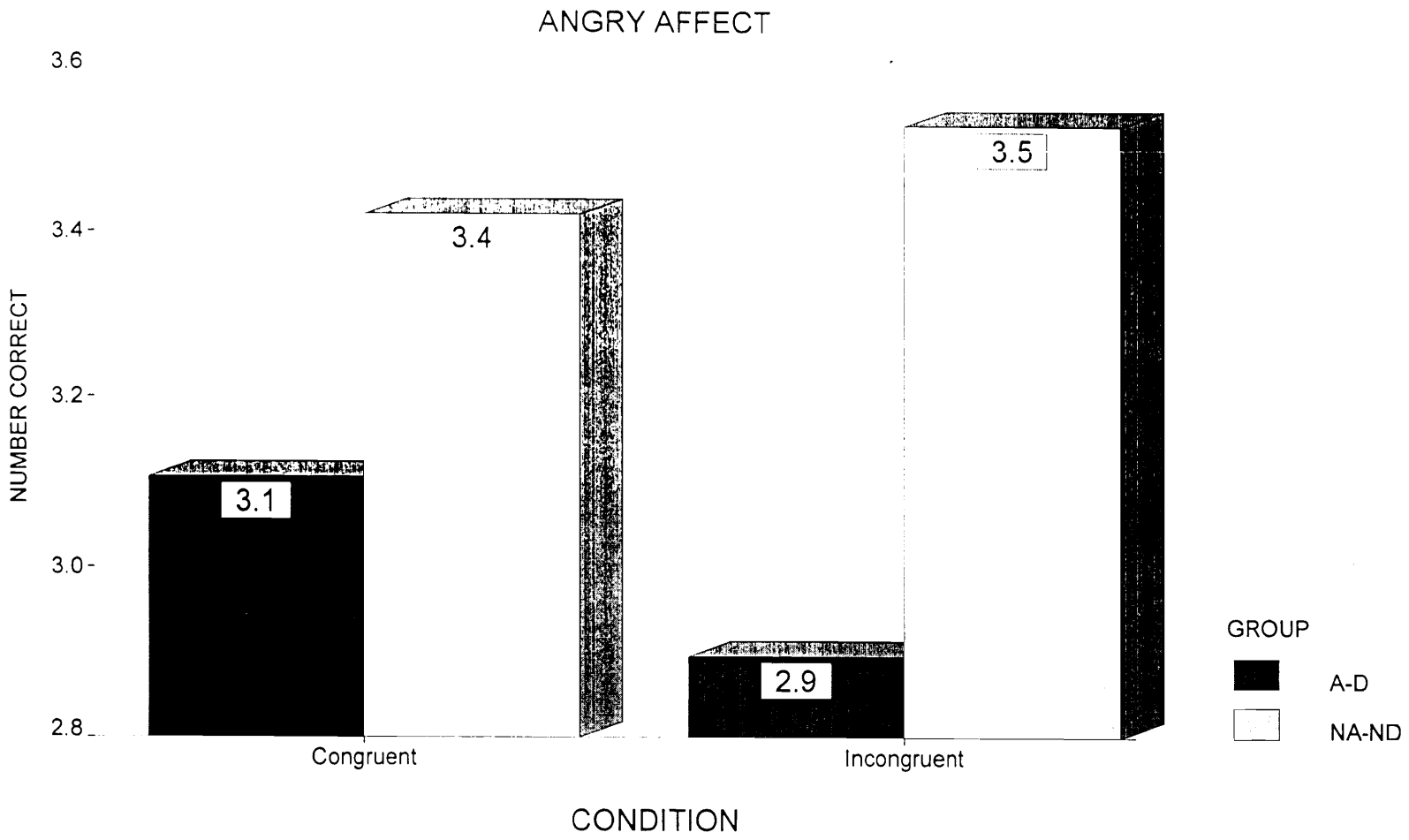


Figure 3
Accuracy of identification of angry affect within congruent and incongruent condition by subject group.

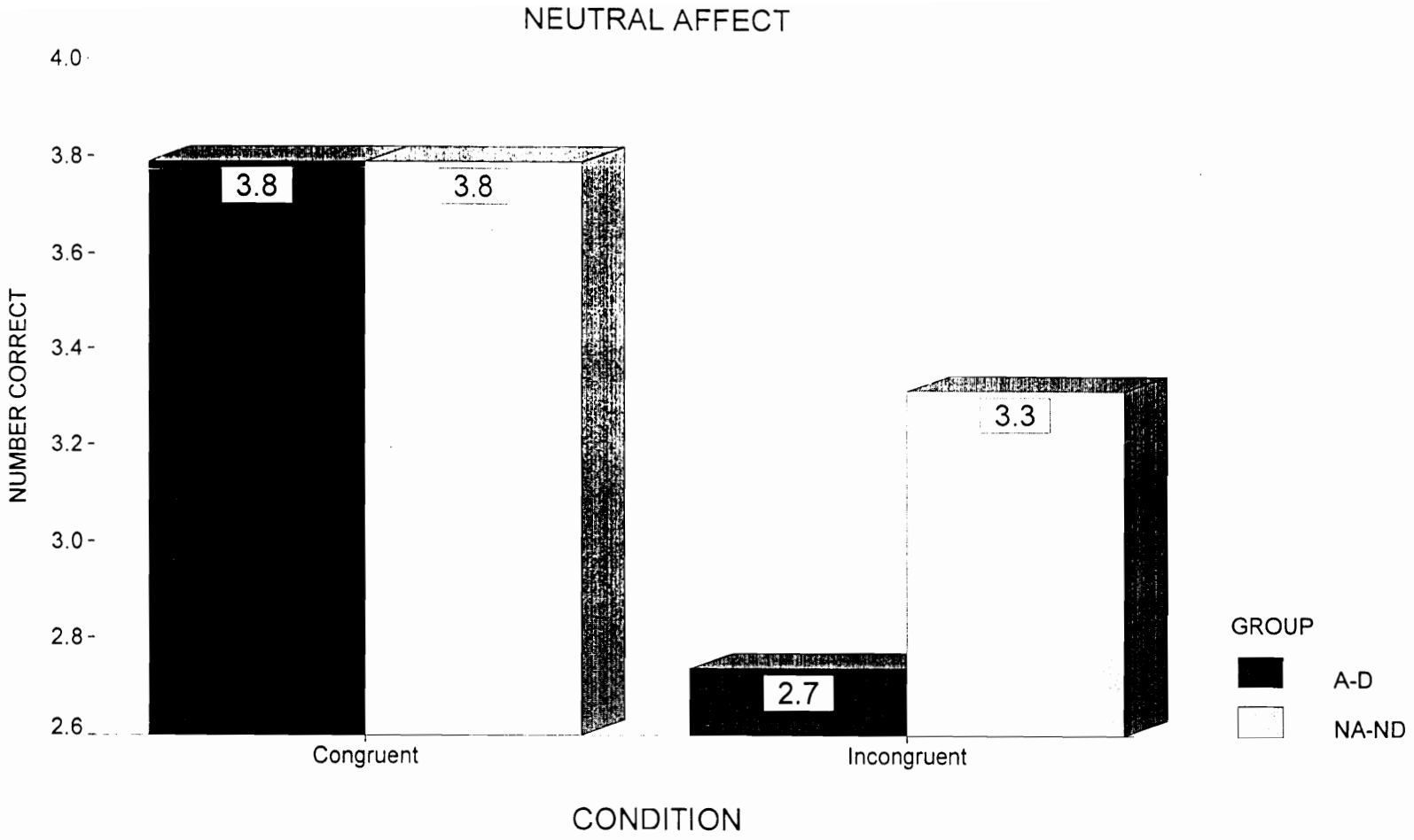


Figure 4
Accuracy of identification of neutral affect within congruent and incongruent condition by subject group.

significantly more accurate than anxious-depressed subjects in the incongruent condition (see Table 1). See Figures 5 and 6 for a summary of the above results.

To determine whether specific affects were identified more accurately within groups, pairwise comparisons were conducted for each affect in the congruent condition. For the anxious-depressed group, sad affect was identified more accurately than both happy affect, t (18) = 2.97 $p < .004$, and angry affect, t (18) = 1.79 $p < .045$. Neutral affect was identified more accurately than sad affect t (18) = 2.05 $p < .028$. Thus, in the congruent condition, the anxious-depressed group was most accurate at the identification of neutral affect, followed by sad affect, angry affect, and happy affect, in that order. For the non-anxious, non-depressed group in the congruent condition, pairwise comparisons revealed that sad affect was identified more accurately than both happy affect, t (17) = 2.12 $p < .025$, and angry affect, t (17) = 3.43 $p < .002$. Neutral affect was identified more accurately than angry affect t (18) = 1.94 $p < .035$. There were no significant differences in identification between neutral and sad affect. In the incongruent condition, anxious-depressed subjects identified angry affect more accurately than sad affect t (18) = 2.07 $p < .027$. None of the other affects differed significantly in accuracy of identification. In contrast, non-anxious, non-

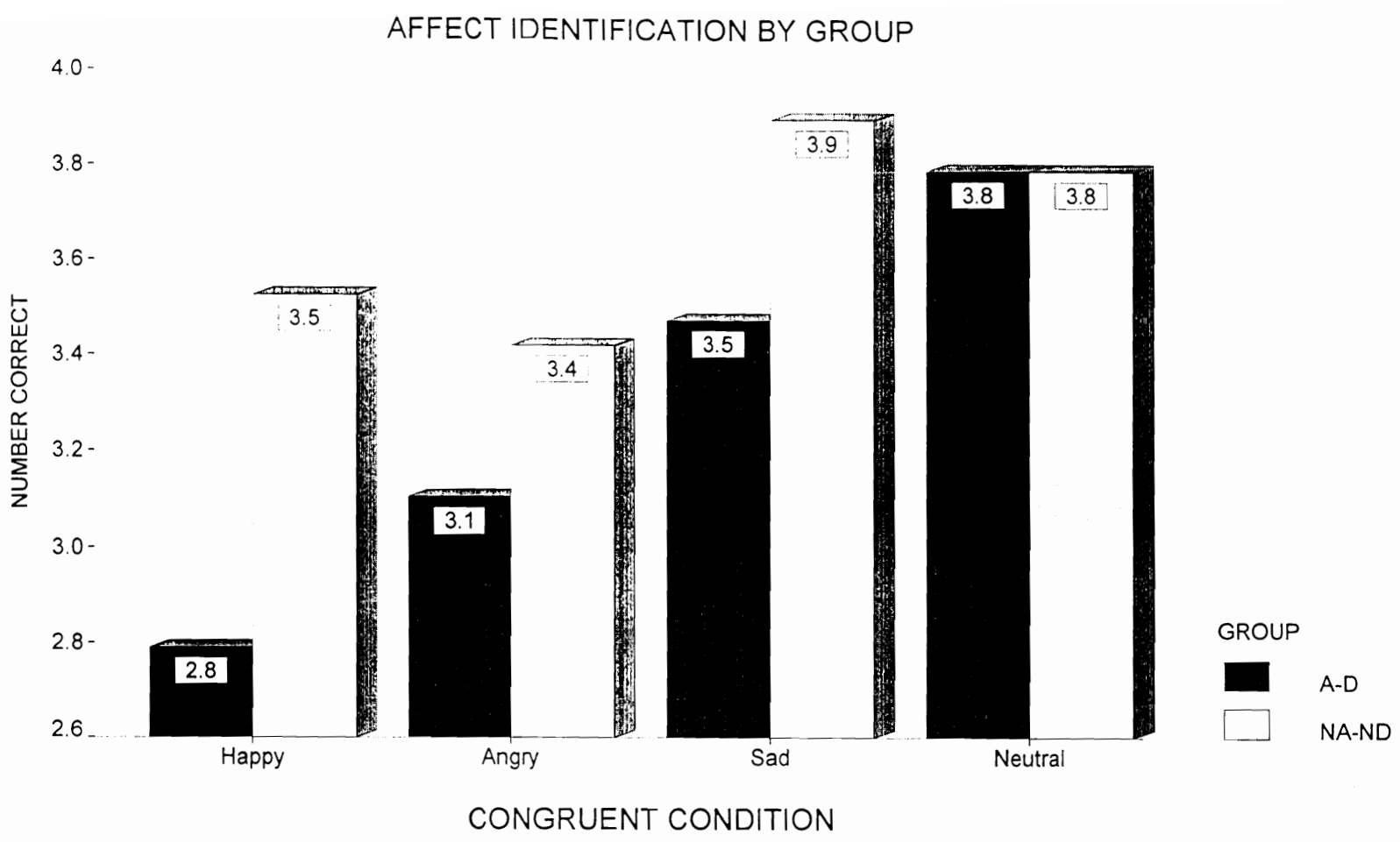


Figure 5
Relative accuracy of identification of four affects in congruent condition by group.

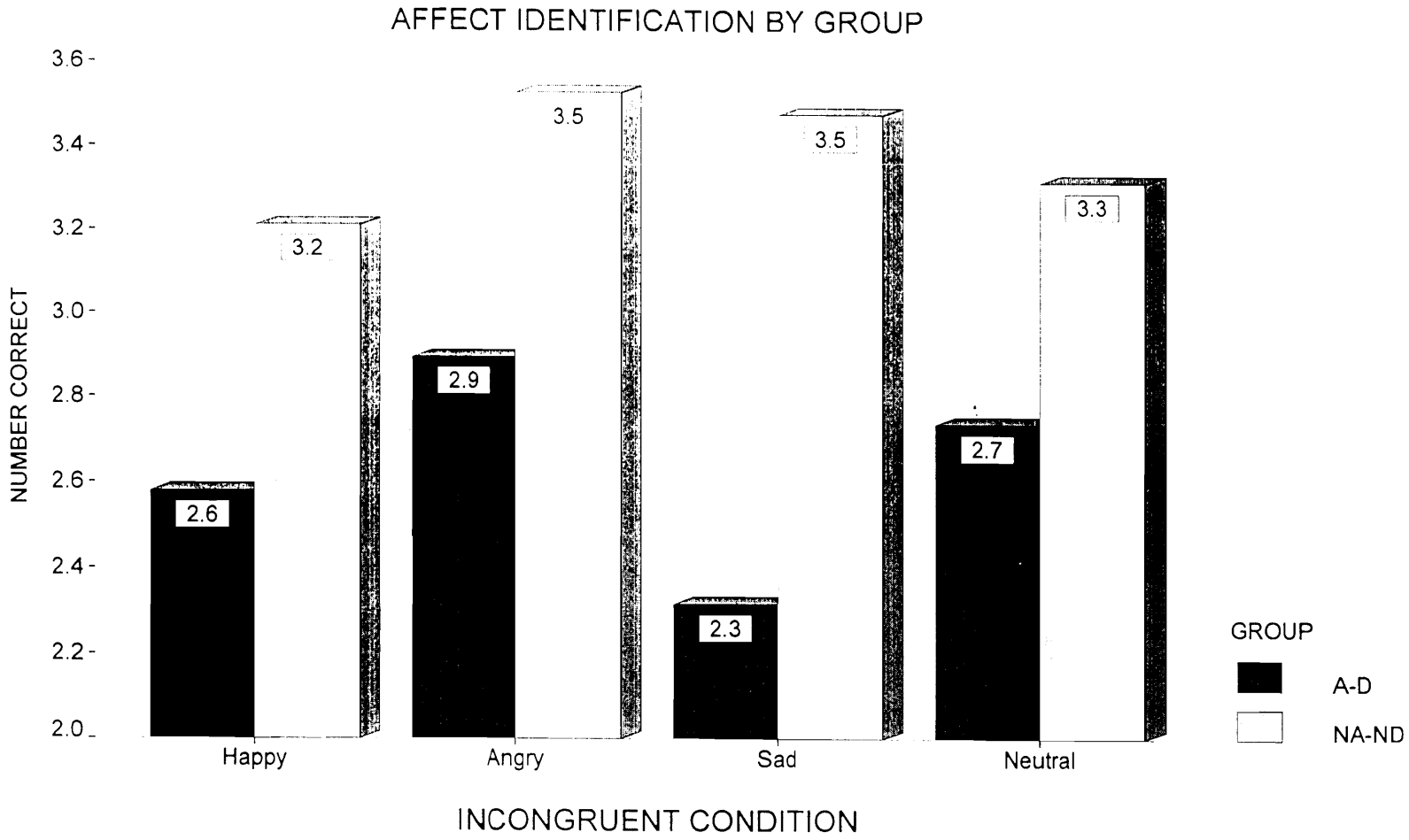


Figure 6
Relative accuracy of identification of four affects in incongruent condition by group.

Table 1

Means and Standard Deviations for Each Affect by Congruent and Incongruent Conditions by Group

		Anxious Depressed		Non-Anxious Non-Depressed	
Affect	Cond	Mean	S.D.	Mean	S.D.
Happy	C	2.79	1.08	3.50	.71
Happy	I	2.58	1.17	3.33	.77
Sad	C	3.47	.91	3.89	.32
Sad	I	2.32	1.49	3.44	.86
Angry	C	3.11	.94	3.39	.61
Angry	I	2.89	.94	3.56	.51
Neutral	C	3.79	.54	3.78	.54
Neutral	I	2.74	.87	3.33	.97

C = Congruent Affect

I = Incongruent Affect

depressed subjects exhibited no differences in accuracy of affect identification.

Dichotic Listening

Two three-factor mixed design repeated measures analyses were used for this analysis, with the fixed factor of Group (2) and the repeated measures of Condition (2) by Ear (2). First, an ANOVA was performed to determine whether there was a significant difference in laterality of identification in the affect Condition versus the word Condition. Two performance variables, represented by percent correct scores for the affect Condition (summed across happy, sad, angry, and neutral affects) and the word Condition (summed across tower, power, bower, and dower), by left and right Ears were analyzed. There was a main effect for Condition, F (1, 36) = 4.08, $p < .026$, and a Condition by Ear interaction, F (1, 36) = 36.15, $p < .000$ (see Figure 7). There were no other main effects or interactions. Targets in the affect Condition were identified more accurately than targets in the word Condition. Further, affect targets were identified more accurately by the left ear than by the right ear, and word targets were identified more accurately by the right ear than by the left ear, suggesting that the expected lateralization of affect perception to the right hemisphere, and of word perception to the left hemisphere was confirmed. A second ANOVA was

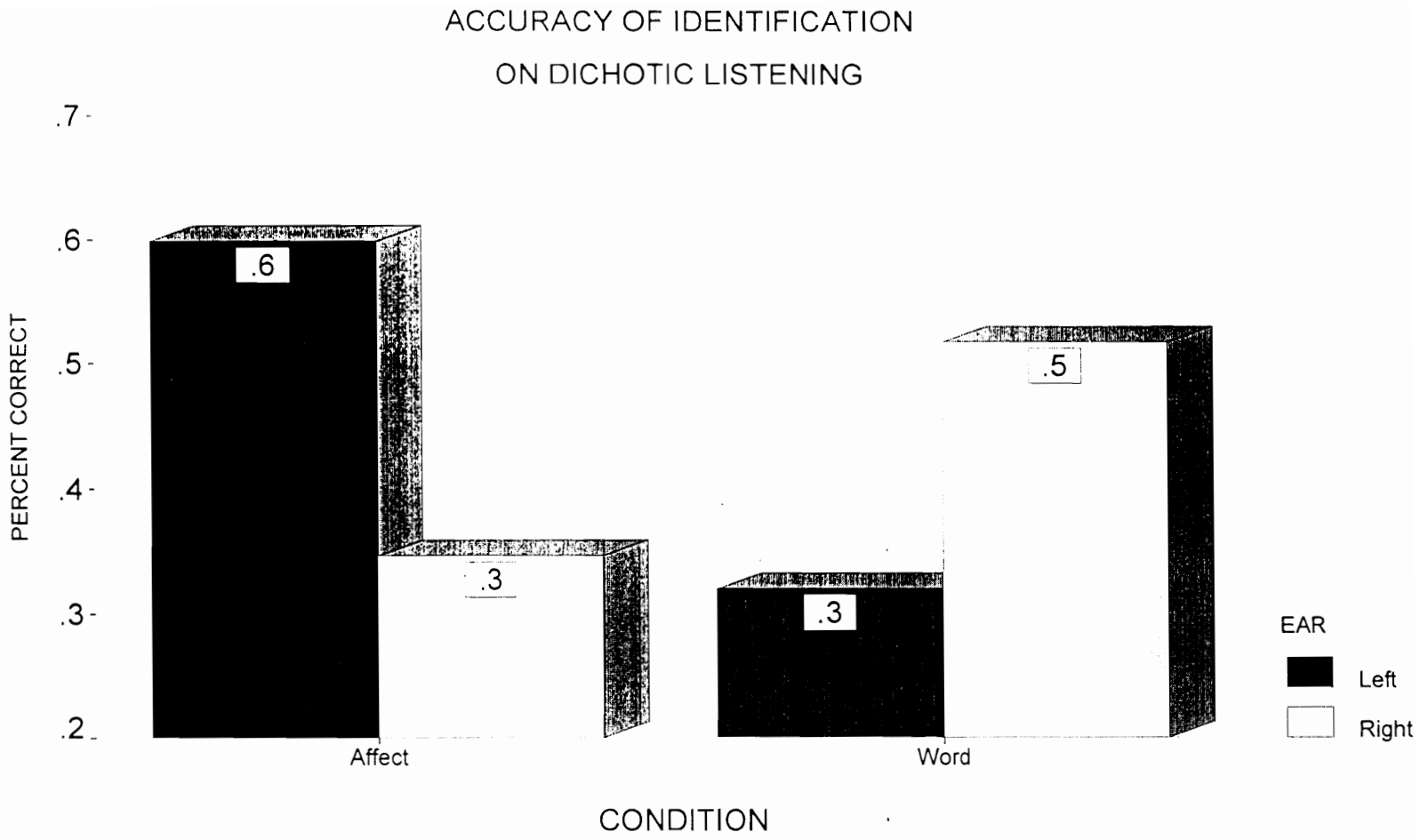


Figure 7
Accuracy of identification of affect and word condition by left and right ear.

performed on the Affect condition using the fixed factor of Group (2) and the repeated measures of Ear (2) by Affect (4), to determine whether there were differences in the accuracy of identification of specific affects, and whether laterality (relationship between percentage correct scores for left and right ear) varied by ear and/or group. Eight performance variables represented by percent correct scores for anxious-depressed and non-anxious non-depressed groups, for happy, sad, angry and neutral affects, nested within left and right ears were analyzed. A three-way ANOVA on the variables Affect by Ear by Group revealed a main effect for Affect, $\underline{F}$ (3, 34) = 7.62, $\underline{p} < .001$, and a main effect for Ear, $\underline{F}$ (1, 36) = 22.06, $\underline{p} < .001$, together with a significant Ear by Affect interaction, $\underline{F}$ (3, 34) = 4.25, $\underline{p} < .006$. Groups did not differ in accuracy of identification. Happy, sad, angry, and neutral affects were identified more accurately by the left ear than by the right ear. Angry affect was identified more accurately than happy affect across ears $\underline{F}$ (1, 36), = 16.52, $p < .001$. Likewise, sad affect was identified more accurately than angry and happy affect, $\underline{F}$ (1, 36), = 5.55 $\underline{p} < .012$ (see Figure 8). To specific affects, percentage correct scores for each affect by each ear were analyzed using pairwise comparisons. Results revealed that angry affect was significantly more

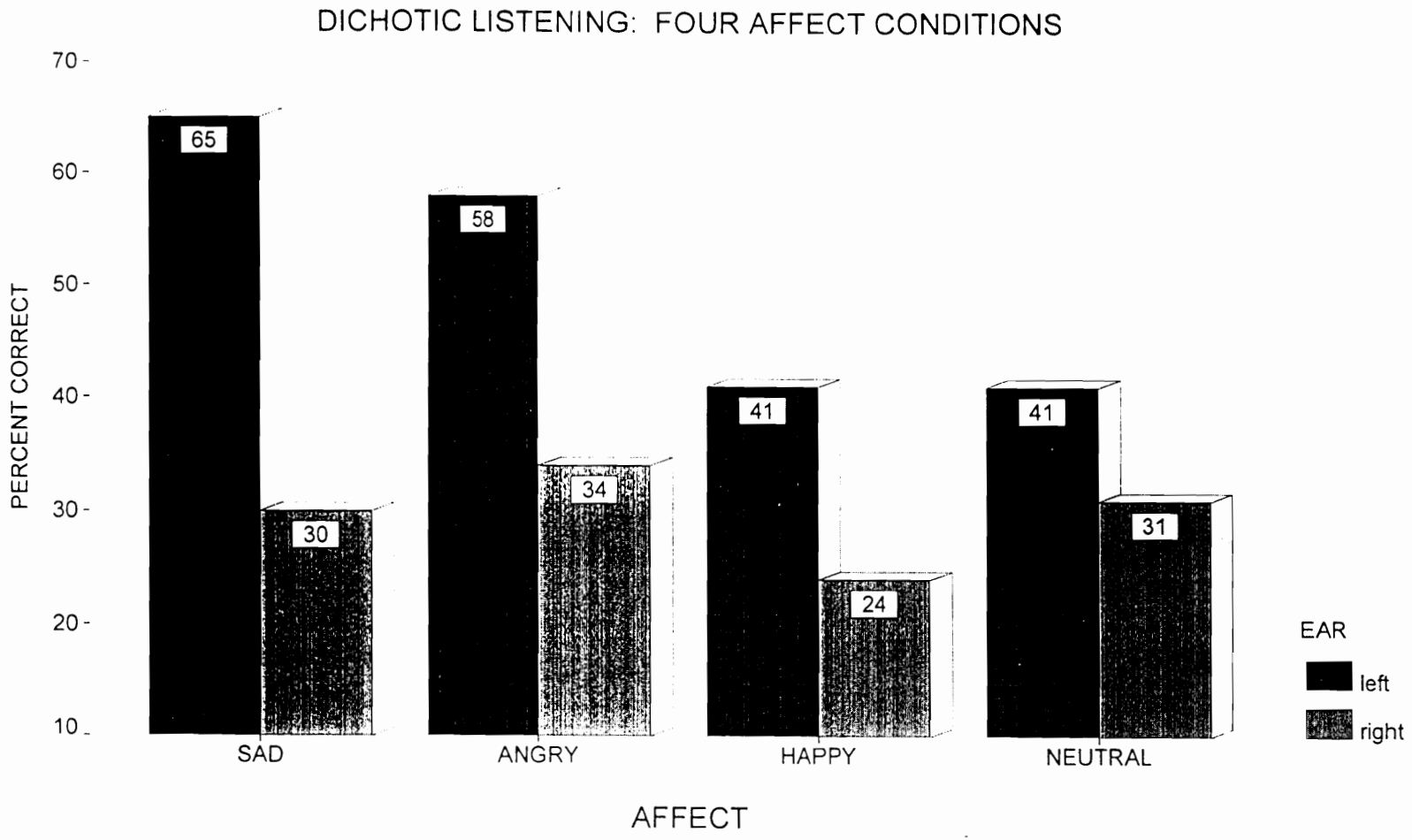


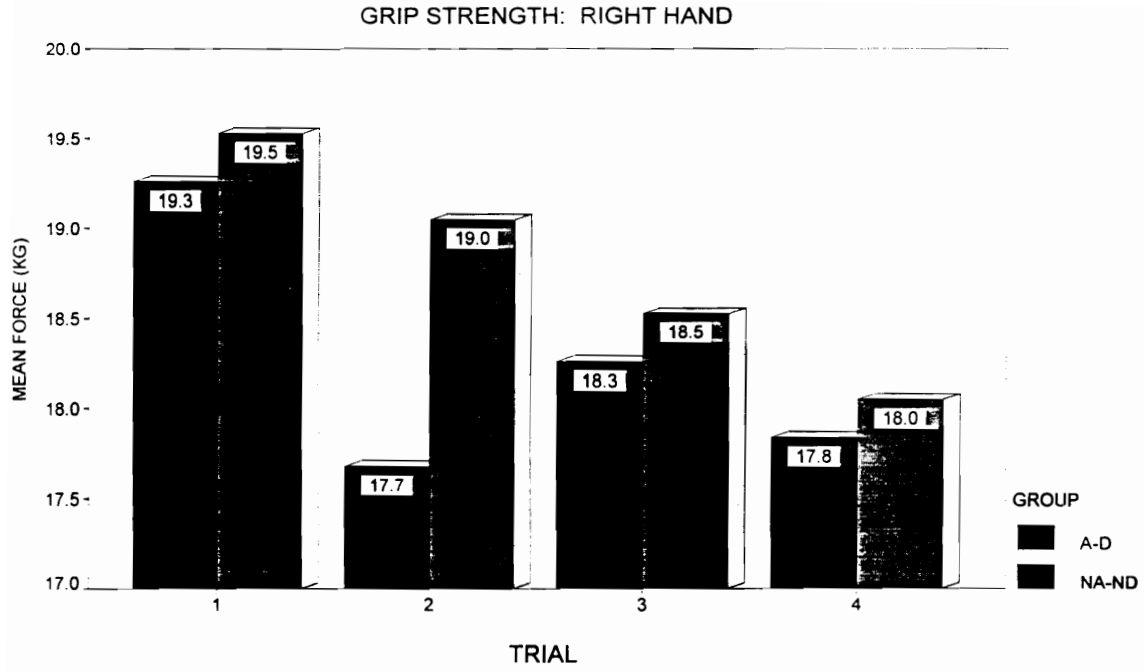
Figure 8
Percentage of correct responses by left and right ears in four affect conditions.

lateralized to the left ear than happy affect t (37) = 1.43 $p < .001$). Angry affect was significantly more lateralized to the left ear than neutral affect t (37) = 2.51 $p < .007$. Similarly, sad affect was more strongly lateralized to the left ear than angry affect t (37) = 1.83 $p < .037$). Further, sad affect was more lateralized to the left ear than happy affect t (37) = 3.21 $p < .002$, and than neutral affect t (37) = 3.29 $p < .001$. Happy and neutral affect were similarly lateralized t (37) = 1.15 $p < 0.13$.

Grip strength

A 3-factor mixed design ANOVA was conducted for the fixed factor of Group (2) and the repeated measures of Trial (4) by Hand (2) for mean force exerted, as measured in kilograms. There was a main effect for Hand, F (1, 36) = 15.62, $p < .01$, a main effect for Trial, F (3, 34) = 13.17, $p < .001$, and a Group by Hand interaction, F (1, 36) = 3.80, $p < .030$. The right hand (mean = 74.12, S.D. = 13.12) was significantly stronger than the left hand (mean = 69.64, S.D. = 12.67 (see Figure 9). Across groups, there was progressively greater fatigue on each subsequent trial with greater grip strength on Trial 1 (mean = 37.89 S.D. = 6.50) to determine whether laterality of identification between than on Trial 4 (mean = 34.46 S.D. = 6.83), F (3, 34) = 7.13 $p < .001$.

To assess fatigue within groups, pairwise comparisons



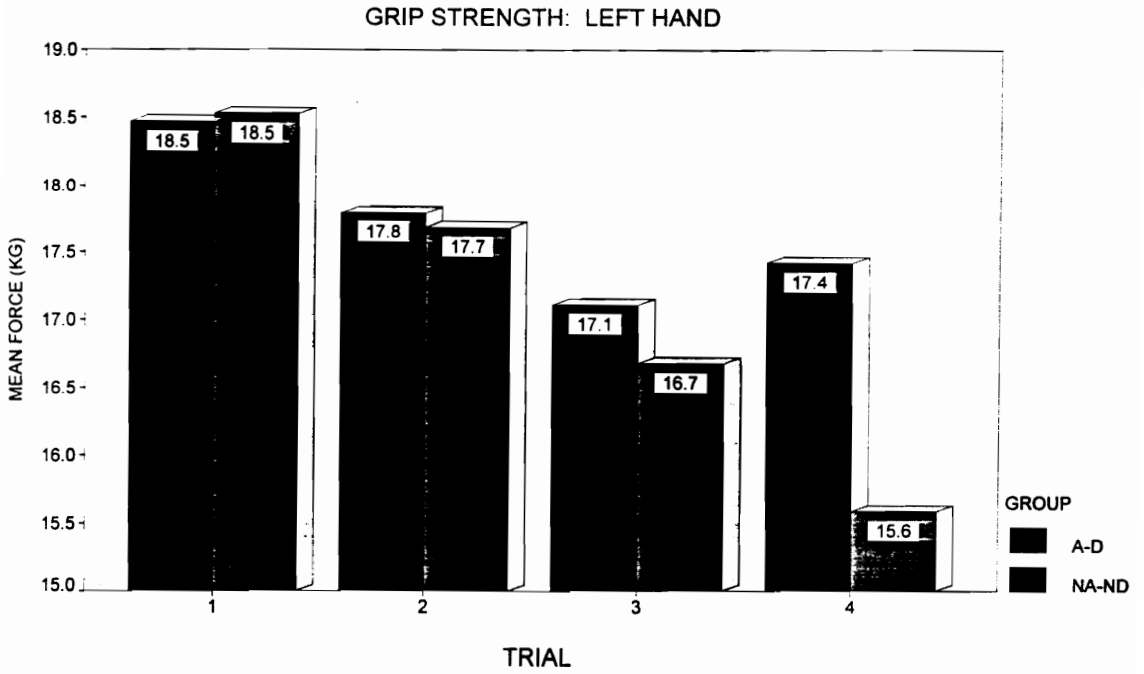


Figure 9
Comparison of Grip Strength by Hand

were performed for each group by hand and trial. The anxious-depressed group exhibited no stepwise or significant decline in left hand grip strength from Trial 1 to Trial 2, or from Trial 3 to Trial 4. There was a significant decrease in grip strength between Trial 1 and Trial 3, t (18) = 2.97 $p < .004$. This was, in turn, reflected in a significant difference between Trial 1 and Trial 4, t (18) = 2.78 $p < .006$. In contrast, the non-anxious, non-depressed group exhibited a stepwise pattern of left hand fatigue, with significant decreases in grip strength from Trial 1 to Trial 2, t (18) = 4.09 $p < .001$, from Trial 2 to Trial 3, t (18) = 2.47 $p < .012$, and from Trial 1 to Trial 4, t (18) = 2.42 $p < .013$. These results suggest that the anxious-depressed group maintained grip strength longer with the left hand before fatiguing, compared to the non-anxious, non-depressed controls, who began declining after the first trial. Comparison of right hand means revealed that the anxious-depressed group exhibited a significant decrease in grip strength between Trial 1 and Trial 2, t (18) = 3.52 $p < .001$, with no significant change thereafter, suggesting that anxious-depressed subjects fatigued quickly and continued to perform at that level. In contrast, the non-anxious, non-depressed group demonstrated a stepwise pattern of gradual fatigue, with a significant decline in grip strength from Trial 2 to Trial 3, t (18) = 1.76 $p < .048$,

and from Trial 1 to Trial 4 t (18) = 3.20 p < .003.

To determine whether groups were differentially lateralized, a two factor mixed design ANOVA with the repeated measures of Hand (2) by Trial (4) was conducted for each group separately. For the anxious-depressed group, there was a main effect for Trial F (3, 16) = 6.16 p < .003, and a Hand by Trial interaction F (3, 16) = 3.18 p < .027. Left and right hands did not differ significantly F (1, 18) = 2.41 p < .069, reflecting a lack of expected Right < Left lateralization. For the non-anxious, non-depressed group, there was a main effect for Hand (reflective of lateralization) F (1, 18) = 14.89 p < .001, and a main effect for Trial F (3, 16) = 9.08 p < .001. There were no other main effects or significant interactions. There was a significant difference between right and left hands, indicating that the non-anxious, non-depressed group displayed normally lateralized grip strength, including the expected dominant (right) hand advantage (see Table 2).

A two factor mixed design ANOVA was used to analyze perseveration, with the fixed factor of Group (2) and the repeated measure of Perseveration/Hand (2). One performance variate, perseveration, was calculated by dividing subject scores at half strength by subject scores at full strength, for right and left hands. Results revealed a main effect for Hand, F (1, 36) = 3.50 p < .035. There were no other main

Table 2

Grip Strength by Trial for Right and Left Hands:

Anxious Depressed Group

Trial	1	2	3	4	Tot
Right Hand					
Mean	19.26	17.68	18.26	17.84	73.00
S.D.	3.09	3.22	3.02	3.37	11.93
Left Hand					
Mean	18.47	17.79	17.11	17.42	70.79
S.D.	3.03	3.05	3.09	3.42	11.65

Non-Anxious Non-Depressed Group

Trial	1	2	3	4	Tot
Right Hand					
Mean	19.52	19.05	18.53	18.05	75.16
S.D.	3.78	3.34	3.95	3.89	14.47
Left Hand					
Mean	18.53	17.68	16.68	15.59	68.48
S.D.	3.72	3.76	3.76	5.16	13.84

effects or interactions. The Left Hand showed significantly greater Perseveration than the Right Hand across groups.

Verbal fluency.

A two factor mixed design ANOVA was conducted for the fixed factor of Group (2) and the repeated measure of Trial (3), for number of words correctly generated. There was a main effect for Group, F (1, 36) = 4.04, p < .026, and a main effect for Trial, F (1, 36) = 10.01, p < .001. There were no significant interactions. Non-anxious, non-depressed boys generated a greater number of words across trials, compared to anxious-depressed boys. The number of words correctly generated in Trial 1 was significantly greater than that on Trial 2, t (37) = 3.05 p < .002 (see Table 3). Similarly, the number of words correctly generated in Trial 3 was reliably greater than that on Trial 2, t (37) = 4.13 p < .001. Trial 1 did not differ from Trial 3. Non-anxious, non-depressed subjects generated a greater number of words on Trial 1 than did the anxious-depressed group, t (36) = 2.63 p < .006. There were no significant differences between groups on Trials 2 and 3, suggesting that the anxious-depressed group improved to the level of the non-anxious, non-depressed group over time.

Sequencing and Alternation: Time

A three-factor mixed design ANOVA was used for this analysis, containing the fixed factor of Group and the

Table 3

Mean Number of Words Generated by Groups on Trials: Verbal Fluency

	Condition		
Group	1	2	3
Anxious-Depressed			
Mean	7.21	6.53	9.26
S.D.	2.49	2.55	2.56
Non-Anx Non-Dep			
Mean	9.37	6.95	9.68
S.D.	2.57	2.92	3.28

repeated measures of Condition (Alternation and Sequencing). Two performance variables were analyzed: Sequencing (time in seconds required to connect a series of numbers in order) and Alternation (time in seconds required to connect a number sequence with a letter sequence, in alternation. Analysis revealed a main effect for condition F (1, 36) = 64.14, $p < .001$, and a group by condition interaction F (1, 36) = 2.80 $p < .051$.

Sequencing.

Significantly less performance time was required for both groups to perform the sequencing condition, as compared to the alternation condition. Further, there were no significant differences in performance time between groups within the sequencing condition (See Table 4).

Alternation.

Both groups required a greater length of time to perform the alternation condition than the sequencing condition. The performance time for anxious-depressed subjects was significantly greater than for normal controls.

Sequencing and Alternation: Errors

The second ANOVA contained the fixed factor of Group (2) and the repeated measures of Condition (2). Two performance variables (number of errors committed on the sequencing condition, and number of errors committed on the alternation condition) were analyzed, revealing a main

Table 4

Mean Performance Time in Seconds for Groups on Sequencing and Alternation Task

	Group	
Condition	ANX DEP	N-ANX N-DEP
Sequencing		
Mean	17.02	16.61
S. D.	4.66	5.06
Alternation		
Mean	38.13	29.90
S. D.	19.34	9.63

effect for Group, F (1, 36) = 8.93, $p < .003$. Anxious-depressed subjects made significantly more errors, compared to non-anxious, non-depressed subjects, across conditions (see Table 5).

Concept formation

A one-way ANOVA on the variable Concept by Group (2) revealed a main effect for Group, F (1, 36) = 6.566. As hypothesized, the non-anxious, non-depressed group (mean = 26.61, S.D. = 4.35) was significantly more accurate on concept formation/problem solving than the anxious-depressed group (mean = 22.94, S.D. = 4.09).

Table 5

Mean Number of Errors Committed by Groups on Sequencing and Alternation Task

	Group	
Condition	ANX DEP	N-ANX N-DEP
Sequencing		
Mean	0.58	0.17
S. D.	0.69	0.38
Alternation		
Mean	0.79	0.33
S. D.	0.92	0.49

Chapter 6

Discussion

The present study is significant for a number of reasons. This is the first time, to the author's knowledge, that the neuropsychological consequences of affective state, specifically anxious depression, have been assessed in a sample of suburban middle-class elementary school children not previously identified for emotional disturbance. It is also the first time that the performance of anxious-depressed children has been compared to non-anxious, non-depressed peers taken from the same population. Previous studies have tended to use higher clinical cut-off scores and have generally focused on psychiatrically diagnosed populations. This study is important because a majority of children identified as anxious-depressed were in the subclinical range on measures of both anxiety and depression, yet their performance differed significantly from non-anxious, non-depressed controls. This suggests that even moderate amounts of dysphoria may disrupt specific neurocognitive functioning.

The current investigation predicted that anxious-depressed boys would exhibit functional deficits in the processing of affective prosody, altered laterality on a dichotic listening task and on a measure of grip strength, and poorer performance than normal controls on measures of

executive functioning including sequencing and alternation, flexible problem solving, and spontaneous word generation.

A number of investigators have noted that alterations in affective state are characterized by differential activation of anterior and posterior cortical regions, in addition to changes in hemispheric laterality. Several authors (e.g., Russell, 1980; Russell & Bullock, 1986; Heller, 1990) have proposed that the brain is organized into two distinct neural systems. One system, located in the frontal regions, is believed to be involved in the modulation of affective valence, ranging from pleasant to unpleasant. Pleasant valence has been associated with increased activation of the left frontal region, relative to right; unpleasant valence is thought to involve increased activation of the right frontal region, relative to left. The other system, located in the right parietal region, is involved in generalized autonomic arousal, ranging from high to low. Heller (1993) developed an integrative model of brain functioning during affective processing. Fundamentally, the Heller model denotes the brain as being divided into four quadrants, defined by two axes, valence and arousal. Sadness or depression is theoretically characterized by unpleasant valence, indicative of increased activation of the right frontal region relative to left, together with decreased activation of the right

parietotemporal region relative to left. This model embodies a number of relationships observed by other authors who have focused on specific areas of the cerebrum. For example, Davidson (1992) and Davidson and Tomarken (1989) have extensively studied EEG activation during affective states, and propose that positive affect and left frontal activation are associated with approach behavior, while negative affect and relative right frontal activation are associated with avoidance behavior. Other authors (e.g., Heilman, et al., 1978) have argued for the existence of a corticothalamic-reticular arousal loop with primary cortical representation in the dorsolateral frontal cortex, maintaining that right hemisphere, and its connections to the frontal lobes modulate primary arousal and attentional processes. Tucker, et al. (1981) has acknowledged the right hemisphere contribution to elementary attentional orienting processes, and studies in this laboratory have observed characteristic right frontal activation in depressed subjects, associated with poor attentional performance in the right hemisphere. Tucker (1993) hypothesized that EEG desynchrony (characteristic of increased arousal) in the right frontal region during the induction of a transient depressed mood may represent an inhibitory function which relates to decreased right posterior activation and performance. Tucker has cited human (Rinn, 1984) and animal studies (Ploog,

1981) to suggest that the experience of emotion must integrate brainstem originated reflexive emotional displays (such as crying or laughter) with experience and ongoing behavior. This potentially occurs by way of corticolimbic mechanisms which recruit emotional significance, integrating ongoing experiences and behavior with reflexive affective representations. Tucker notes that the brain's processing of affect is complex, potentially involving the interaction of multiple systems that are, as yet, only partially understood. Further, this investigator suggests that the Heller (1993) model is a elementary way of understanding cerebral processing of affective stimuli which can be further elaborated to explain its relationship to ongoing affective experience. For purposes of the present discussion, Heller's model is presented as a basic way of organizing the data generated by the current study, and of understanding fundamental affective and arousal dimensions.

This investigation generated a number of hypotheses which were supported. The first major hypothesis was that anxious-depressed boys would be less accurate at the identification of congruent and incongruent affective prosody than non-depressed, non-anxious boys. As predicted, anxious-depressed subjects consistently had greater difficulty with the identification of both congruent and incongruent affect than those who were not depressed or

anxious. This finding suggests that depression in children may have similar functional consequences to those recorded in the presence of right hemisphere lesions in adults (e.g., Heilman, Scholes, & Watson, 1975) and children (Cohen, Prather, Town and Hynd (1990). While both groups were more accurate at discrimination when the affective tone matched the message in the congruent condition, the non-anxious, non-depressed group was clearly superior in the more demanding incongruent condition, for all affects. It was expected that anxious-depressed boys would have difficulty with affect recognition in the incongruent condition. However, they also exhibited significantly less accurate performance than normals on sad and happy affect in the congruent condition. While the availability of content cues helped facilitate the affective perception of these boys, they continued to be impaired relative to boys in the other group. When presented with congruent neutral affect, the performance of the anxious-depressed boys was equal to that of those in the control group. This finding is not surprising when considering that if a child is unable to discriminate happy, sad, and angry affect in speech, what he "hears" would predictably sound neutral. These results are consistent with the hypothesized findings, and are congruent with decreased functioning of the right temporoparietal region, indicated by the Heller (1993) model.

An additional finding of interest was that anxious-depressed boys identified sad affect more accurately in the congruent condition than angry or happy affect, while happy affect was identified least accurately. In contrast, sad affect was least accurately identified by this group in the incongruent condition. One might speculate that the affective state of depression was more salient to the anxious-depressed group, however, it remains to be seen why sad affect was identified least accurately in the incongruent condition. Further investigation of the data shows that differences in the identification of individual affects within the anxious-depressed group were generally not significant. The sole exception was that angry affect was identified significantly more accurately than sad affect, which is congruent with earlier studies. Thus, it might be concluded that the anxious-depressed group was generally unable to process incongruent affective prosody. However, when it became easier to correctly discriminate affect in the presence of a congruent message, they more accurately identified the affect which was congruent with their dysphoric state.

The second major hypothesis predicted that if anxiety and depression are correlated with right hemisphere dysfunction, then children who were high in both would be atypically lateralized in the perception of affect or word

targets, reflective of decreased right posterior functioning. This was expected to be reflected in the relative accuracy with which boys identified dichotically presented affectively valenced words. Anxious-depressed boys did exhibit a trend toward a lower proportion of correct left ear responses, compared to normal boys, which is suggestive of decreased right posterior functioning. These findings are consistent with a number of prior studies which have found relatively less asymmetry in depressed individuals on measures of dichotic listening. Bruder. et al. (1987) found that melancholic depressives had an abnormally large right ear advantage for discrimination of CV nonsense syllables, primarily due to poor left ear performance. The same subjects also failed to show a left ear advantage for discrimination of complex tones. Both findings are consistent with decreased right posterior functioning. Similarly, Tucker, et al. (1981) found decreased left ear performance on a tone discrimination test, and also noted poorer visual imagery in subjects who participated in a depressed mood induction task. Additionally, alpha desynchrony was noted during the imagery condition, indicative of both increased right frontal activation, and decreased left frontal activation. Data collected by Henriques and Davidson (1990) also support increased right frontal activation during depression,

together with impaired visuospatial functioning. Additionally, Heller, Etienne and Miller (1995) found that university students, classified as high in depression, exhibited smaller than normal left hemispatial biases on a face processing task, compared to students who were low in depression. Thus, present findings and previous research are consistent with increased right frontal activation, together with decreased right posterior activation, as proposed by Heller (1993).

The third major hypothesis predicted that anxious-depressed boys would exhibit less grip strength overall, greater fatigue, greater perseveration, and compromised laterality, when compared to those who were not depressed or anxious. A significant interaction showed that anxious depressed boys were significantly less lateralized than normal controls. Inspection of within-group means across trials revealed that the decrease in laterality for the anxious-depressed group was attributable to relatively increased strength in the left hand. This is consistent with hyperactivation of the right frontal region in depression, as predicted by Heller (1993). On the measure of fatigue, normal subjects exhibited gradual stepwise fatigue with both left and right hands, by trials. Anxious-depressed boys also exhibited fatigue across the task, however, it was not significant by trials. Right hand grip strength declined

between the first and second trials, with no subsequent significant changes, suggesting that the right hand fatigued quickly and continued to perform at that level. In contrast, left hand grip strength was maintained for a relatively longer period of time, with no decline between the first and second trials or between the third and fourth trials. Overall, this pattern of performance appears congruent with hyperactivation of the right frontal region, affecting the left hand, and with hypoactivation in the left frontal region, affecting the right hand, again consistent with the proposed model.

The fourth major hypotheses predicted that anxious-depressed children would perform more poorly than their non-anxious, non-depressed counterparts on tasks used to assess left frontal functioning, including the Trail Making Tests, A and B (Trails A and B), the FAS test, and the Concept Formation subtest. Because of the verbal and/or linear, sequential nature of these tasks, they are believed to primarily tap into left frontal functioning. This is contrasted with right frontal functioning, which incorporates holistic processing and visuospatial reasoning. The groups did not differ in performance time on Trails A, a task which involves connecting a single series of numbers sequentially, measuring motor speed and simple sequencing. This finding was not surprising since prior research has

demonstrated that Trails A is easily performed by individuals without brain damage (Reitan & Wolfson, 1985). For Trails B, a more difficult measure involving the alternation of two parallel sequences, the anxious-depressed group exhibited diminished speed and accuracy of response compared to non-anxious, non depressed counterparts. Since the groups did not differ on the motor speed aspects of the Trails A measure, is it reasonable to conclude that differences between the groups on Trails B were attributable to difficulty with the increased cognitive processing required in the alternation condition, suggesting diminished functioning in the left frontal region. Abrams and Taylor (1987) investigated differences in cognitive processing speed between adult depressives and normal controls. When the effect of motor speed was controlled, these investigators found that depressed subjects were significantly slower than normals on speed of cognitive processing. The present findings are also consistent with studies using EEG recordings, which found reduced activation in left frontal regions (e.g., Tucker, et al., 1981), which would be expected to negatively impact efficient cognitive processing.

Not only were anxious-depressed children slower in cognitive processing speed than non-anxious, non-depressed children, but they also committed significantly more errors

across both the sequencing and the alternation conditions. Motor perseveration is common in frontal dysfunction, as is poor active perception (Taylor, Greenspan & Abrams, 1979). Both of these difficulties were exhibited by the anxious-depressed children on this measure, and suggest decreased functioning of the left frontal region of the brain.

The FAS test, a time-limited measure of verbal fluency, was also used to assess frontal functioning in the present study. It was predicted that, compared to non-anxious, non-depressed controls, anxious-depressed children would be able to generate fewer words beginning with a specific letter of the alphabet, within a 60 second time period. Results confirmed that the more emotional children did generate significantly fewer words on the first trial. On the second and third trials, performance was equal to that of the normal controls (but performance typically declines for most subjects on trial 2). Payne (1961) reviewed a number of studies of verbal fluency, concluding that word retrieval and memory were impaired in depressives. Additionally, the task requires mental flexibility (or the ability to shift set given a new set of rules as the target letters change), together with the ability to develop a problem-solving strategy for word generation. While the process used to generate the words was not quantifiably assessed, it is arguable that relatively poorer frontal functioning would

limit spontaneous generation of strategies by which to generate words (e.g., categories of objects, rhyming words, or words beginning with the same phoneme). Several authors have found that speeded cognitive processing is compromised in depressed adults (Abrams & Taylor, 1987; Miller, 1974). Miller found that depressed college students were significantly slower at solving anagrams than non-depressed controls. Hypothetically, these results may suggest that anxious-depressed boys had greater difficulty initially developing a strategy by which to structure the task.

Frontal functioning was also compromised in the anxious-depressed group on a test of verbal reasoning, the Concept Formation subtest. This task also measures hypothesis testing and the ability to shift set, keeping several categorical problem-solving principles in mind which are used to consider possible solutions to the problems.

The Trail Making Test, Verbal Fluency, and the Concept Formation subtest all measure frontal executive functioning, including the capacity for hypothesis testing, verbal abstract reasoning, stepwise planning and flexible problem solving, organization and prioritization of details, self-regulation of affect, motor activity, and cognitive skills, sustained attention, concentration, and social judgement. Individuals with frontal dysfunction frequently have difficulty with attention and concentration,

distractibility, impulsivity, task initiation and completion, motivation, cause and effect reasoning, spontaneity, and social interaction.

Taken together, the findings of the present study present a strong case for the existence of functional deficits in cognitive, sensory perceptual, and motor systems as a result of mild to moderately high levels of anxiety concurrent with depression in children. Implicated in such deficits are increased activation of the right frontal region, together with decreased activation of the left frontal and right posterior regions. Such a model was proposed by Heller (1993) based on a body of research conducted with depressed adults, and is congruent with the findings of other researchers. Present findings suggest that 9 to 11 year old boys with depression and anxiety may be subject to many of the same cognitive and perceptual difficulties documented in depressed adults. Additionally, the subjects used in this study did not, for the most part, exhibit clinical levels of anxiety and depression. This suggests that the differential neurocognitive responses noted between the groups are potentially an underestimation of the effects which might be observed in children hospitalized for more severe levels of depression and anxiety.

The present findings are theoretically meaningful for a

number of reasons. First, they provide initial confirmation, subject to verification by subsequent studies, that anxious-depressed prepubertal boys experience similar sensory and cognitive processing deficits to those found in depressed adults. Second, the functional deficits noted in this study were hypothesized based on observation and investigation of functional deficits in depressed adults, or those with neurological compromise involving relative activation of the right posterior hemisphere, and the right and left frontal regions. As such, the present study represents a theory-driven attempt to measure such deficits in children. Further, the measures used were selected based on their acknowledged usefulness in assessing function in the specific regions of interest. Third, the results of this study are congruent with existing theoretical models of hemispheric dysfunction as a result of depression, which have been integrated in a simple fashion by Heller (1993). While several investigators (e.g., Tucker, 1993; Buck, 1993) conceptualize the integration of higher functioning systems into Heller's prototypical model, including the potential inhibition of posterior arousal/activation by frontal systems, and the inclusion of corticolimbic networks which implement meaning, by way of experience and memory into brainstem patterns of reflexive affective response, there is reasonable agreement with the model as a fundamental way to

conceptualize affective processing.

In addition, this study has important clinical implications for the development and learning of children who are depressed. First, the data suggests that anxious-depressed children's interpersonal interaction with their environment is significantly compromised, both receptively and expressively. Decreased right posterior functioning predictably limits not only the processing and interpretation of affective prosody, but non-verbal information from other channels as well, including facial expressions, gestures, and kinesthetic movement. Thus the depressed child predictably lacks crucial feedback from his environmental context. Social interactive behavior is generally regulated by feedback as to behavioral expectations, and suitability of response. Without such information, the child cannot respond appropriately and is often perceived as "strange" or "annoying" by the people around him. Thus, the potential exists for social isolation, decreased self-esteem, and resultant internalizing or externalizing maladaptive behavior.

In addition to the potential negative impact of right posterior dysfunction on a depressed child, frontal dysfunction may be even more devastating. Because his capacity to solve problems, logically organize information into meaningful structures, sustain his attention, and

inhibit distracting information is compromised, the depressed child will predictably have difficulty learning, and remembering what he learns. He will find it difficult to accomplish tasks, and to effectively meet the challenges of everyday living. Additionally, thought processes may be perseverative, and he will find it difficult to think of options, including effective ways of dealing with his negative feelings. In other words, the brain function which corresponds to his depressed state may act to maintain that state by making everyday life seem like an overwhelming burden. As time passes, difficulty in learning may compound, since future learning is often based on present learning. The depressed child may experience a decline in academic competence, which can potentially lead to poor self-esteem and behavioral difficulties. Finally, it appears possible that many of the dysfunctions which clinicians and educators diagnose as executive functioning difficulties, learning disabilities, Attention Deficit Hyperactivity Disorder, and Conduct Disorder, are behavioral manifestations of anxiety and depression. This possibility suggests that those which are related to depression, may be responsive to relatively short-term pharmacological treatment, without the need for stimulant medication or special classroom placement. Given the pervasive manner in which anxious -depression may affect many functional systems, appropriate assessment of

socioemotional functioning should be an integral part of any placement evaluation.

The present paper has raised a number of questions. An appropriate question at this point involves a direction for future research. If depression in children, and its neurocognitive implications are as pervasive as this study suggests, what can be done to avert such difficulties in the future? First, more children must be studied, in an effort to replicate the present study, and also to investigate the possibility of children with "pure" anxiety and depression. If these children can be found, it may be possible to study the independent contributions of anxiety and depression to the negative affectivity constellation of feelings and behaviors, and to learn more about corresponding brain activation. Additionally, it will be important to study a variety of populations, including females, children in both rural and urban living centers, and children who have one or more depressed family members, in order to understand differential responsiveness within specific populations. Further, a number of investigators have acknowledged that self-report measures, (including the questionnaires used in the present study), are a problematical means of investigating anxiety and depression. Concerns include overlapping symptoms with poor discriminability of items, together with inaccurate self-reporting. Future studies

should possibly seek to develop a single questionnaire measure with factors which load on different aspects of anxiety and depression, and which produce factor scores which may be evaluated independently. Additionally, most investigators agree on the importance of multiple measures of depression and anxiety, assessing a child's functioning across multiple domains. While this was not possible to do with the present volunteer sample of "normal" school children, it should be an important consideration of future studies. The problems cited above contribute to ongoing difficulty with identifying and properly treating depressed children. This concern is particularly important for studies such as the present, which included a significant proportion of children who were subclinically depressed (mild to moderate). Such children may not demonstrate outward signs of depression, yet exhibit compromised functioning in areas such as those measured here.

It is important to remember that until relatively recently, depression was not considered a valid diagnosis in children. Investigators have made important strides in quantifying and qualifying childhood depression as an entity. However, there is much additional work to be done in order that clinicians and educators may have badly needed information by which to accurately evaluate the effects of emotional disturbance upon a child's educational and

psychosocial functioning. This study represents one small step towards that process.

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CURRICULUM VITAE

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EDUCATION:

Virginia Polytechnic Institute & State University
Ph.D., Psychology, April, 1996
Specialization: Neuropsychology, Clinical Child Psychology

Virginia Polytechnic Institute & State University
M.S., Psychology, December, 1989
Specialization: Developmental Psychology

Loretto Heights College, Denver, Colorado
B.S., Psychology, May, 1985

PROFESSIONAL EXPERIENCE:

Clinical Counseling and Assessment

September, 1995 to Present

Postdoctoral Fellowship in
Pediatric Neuropsychology
Medical College of Georgia
Child Neuropsychology Service
Section of Child Neurology
Augusta, Georgia
Direct Supervisor: Morris J. Cohen
Director, Child Neuropsychology Service

Child Neuropsychology provides pre and post

assessment as part of the Epilepsy, Oncology, and Sickle Cell programs at MCG. Additionally, child neuropsychology consults with Pediatrics for ADHD assessments, Neurology for assessment and follow-up with various developmental disabilities, and operates an outpatient clinic for Learning Disability and forensics assessments. The fellow acts as the clinician for all phases of the assessment, treatment planning, feedback, and report writing.

September, 1994 to September, 1995

Rush Presbyterian-St. Luke's Medical Center
Department of Pediatrics/Pediatric Psychology
Chicago, Illinois
Direct Supervisor: Warren D. Rosen, Ph.D.,
Director, Pediatric Neuropsychology Service

Responsible for neuropsychological assessment, treatment planning, and report writing under the supervision of Dr. Rosen. Each assessment involves 9 hours of testing utilizing a flexible battery approach. Children referred to clinic generally present with symptoms of learning disability, attention deficit disorder, mental retardation, epilepsy, autism, closed head injury, and a variety of related behavioral disorders.

July, 1993 to July, 1994

Clinical Psychology Internship
University of Chicago Hospitals
Chicago, Illinois
Direct Supervisors: Dr. Cathy Lord, Director of Child Training; Dr. Neil Pliskin, Director, Neuropsychology Service, Director of Clinical Training

Involved responsibility for diagnostic assessment and long-term therapy with children and families focused on their emotional, cognitive, and psychosocial needs. A major focus of experience was 6-month major rotations in both Adult and Child Neuropsycholgy, focusing on a wide range of cases including various types of dementia, epilepsy, traumatic brain injury, tumor, developmental disability, learning disability, ADHD, and psychiatric disorders in both inpatients and outpatients. Additional rotations in the Developmental Disabilities Clinic, specializing in autism, and the Parent Infant Development Service which specializes in the assessment and treatment of adjustme

nt disorders in infants and young children. Major emphasis was placed on diagnostic evaluations and report writing. Theoretical orientation mixed, although child treatment cases were generally psychodynamically oriented, with behavioral and cognitive behavioral treatment employed when warranted.

September, 1991 to June, 1993

Southwest Virginia Mental Health Institute
Marion, Virginia
Direct Supervisor: Dr. Richard Mears, Chief, Psychological Services

Worked as a Masters level psychologist under the auspices of Virginia Tech at the State Psychiatric Hospital, a full-service psychiatric facility. During the 1 1/2 year placement, I worked on the intake units, on geriatrics, and on long-term care (primarily severely decompensated organic patients). Duties included psychological and neuropsychological assessment, behavioral treatment planning and consulting with nursing staff regarding milieu management of difficult patients. This was a 20-hour per week placement.

April, 1992 to June, 1992 (overlapped with above)

Veterans Administration Medical Center
Salem, Virginia
Direct Supervisor: Dr. James Lanter, Chief, Psychology Services

Performed neuropsychological assessments, on inpatients, primarily involving dementia, with various psychiatric and medical complications. Assessment primarily utilized the Halstead Reitan Neuropsychological Battery, together with other selected, commonly utilized neuropsychological measures. This was a 32 hour per week temporary position.

May, 1990 to May, 1991 (except summer break)

Psychological Services Center and Child Study Center
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24060
Direct Supervisor: Dr. David Harrison, Clinical Neuropsychologist

Worked as a member of the neuropsychology practicum team during the school term. Responsible for neuropsychological assessment and treatment of school-aged children, and adults, particularly relating to learning disabilities and closed head trauma. This placement typically involved one assessment per week, and three hours of group and individual supervision per week.

June, 1991 to September, 1991 (overlapped with above)

Children's Hospital
Department of Pediatric Psychology
300 Longwood Avenue
Boston, MA
Direct Supervisor: Dr. Janice Ware, Director
Pediatric Psychology

Worked as a Pediatric Psychologist in the Department of Pediatrics. Rotated among clinics specializing in Preschool Function, Developmental Disabilities, and School Function on a multidisciplinary team. Duties included assessment of psychological and developmental functioning of children ranging in age from 2 months to 12 years, assessment of family systems, treatment planning, and treatment implementation. Clinics focused on assessment, diagnosis, and treatment planning for a variety of child dysfunctions, including Attention Deficit Disorder, Learning Disabilities, Behavioral Problems, Psychopathology secondary to trauma, and Developmental Disabilities. This was a 40-hour per week summer externship.

June, 1990 to August, 1990

The Kennedy Institute
Behavioral Psychology Department
707 North Broadway
Baltimore, Md. 21205
Direct Supervisor: Dr. Wayne Fisher, Clinical Director

Worked as a therapist on the severe behavior unit with children diagnosed with mental retardation and varying medical and developmental disabilities. As primary therapist for a five-year-old boy diagnosed with severe mental retardation, pervasive developmental disorder and a feeding disorder, I did high intensity behavior management treatment planning, therapy, and case management including daily evaluation of treatment

progress and weekly reporting. Also participated in supervision and treatment of other children on the unit, most of whom were under age 10. This was a 40-hour per week summer externship.

January, 1990 to May, 1990

Psychological Services Center and Child Study Center
Virginia Polytechnic Institute and State University
Blacksburg, Va. 24060

Worked as a therapist on the child practicum team. Did psychological assessment and counseling of school-aged children and their families, principally in the areas of attention deficit disorder, hyperactivity, learning disabilities and conduct disorders.

June, 1989 to August, 1989

Psychiatric Institute of Montgomery County
Rockville, Maryland
Great Seneca, Rockville, Maryland
(these institutions are both operated by P.I., Montgomery County).

Worked as a Psychiatric Technician on the hospital nursing pool. Work focused on behavior management and brief therapeutic intervention with children ages 5-12 diagnosed as ADHD or conduct disordered, and adolescents. Also worked on the adult unit, and the NEU (neuropsychiatric evaluation unit). This was a 40-50 hour per week summer position.

July, 1987 to August 15, 1988

Mount Airy Psychiatric Center
Denver, Colorado

Worked as Mental Health Worker (psych tech) on the hospital nursing pool. Worked mostly with chronic, severely disabled adults on the double-locked ward. Also worked with hospitalized adolescents in the residential treatment facility. Duties included milieu management (both on the unit and in 1:1 patient care with highly disruptive and/or suicidal patients). Did brief goal-directed therapy in conjunction with physician's treatment plan, group therapy sessions, patient recreation groups. This was a part-time summer placement while in graduate school.

Research:

Publications in Reviewed Journals:

Harrison, D.W. & Emerson, C.E.
The Fortec blood pressure/pulse rate monitor Model MI-100. Journal of Ambulatory Monitoring, December, 1990.

Emerson, C.E. & Harrison, D.W. (1990).
Anger and denial as predictors of cardiovascular reactivity in women. Journal of Psychopathology and Behavioral Assessment, Vol. 12(4), 271-283.

Published Abstracts:

Emerson, C. E. & Harrison, D. W. (1990).
Anger and denial as predictors of cardiovascular illness in women. APA Division 6 Newsletter.

Master's Thesis:

Anger and Denial as Predictors of Cardiovascular Reactivity
December, 1989

Preliminary Written Examination:

Infant Directed Speech Versus Depressed Maternal Speech: Potential for Differential Development of Neural Activation Patterns

Doctoral Dissertation:

Sensory and Cognitive Processing Deficits in Anxious Depressed Children: A Neurobehavioral Study

Research Grant:

Women's Research Institute
$2500 for study of women's health issues: Relationship between anger, denial and cardiovascular reactivity in working females.

Other Research Experience:

Clinical Intern:

Participated in the cognitive developmental assessment of preschool children born to cocaine addicted mothers.

Research Assistant:

Participated in data collection and the analysis of videotapes on a project which longitudinally followed the development of the infants of depressed mothers.

Professional Memberships:

American Psychological Association, Psi Chi.

Presentations:

Emerson, C.E. & Harrison, D.W. Anger and denial as predictors of cardiovascular reactivity. Presented at the American Psychological Association annual conference, August, 1990.

Awards:

Travel award for presenter at 1990 APA Conference, Boston, Ma.

Teaching:

Teaching Assistantships:

Virginia Polytechnic Institute and State University

1987-88 Intro Psychology Discussion

1988-89 Cognitive Psychology - Lecture TA
Personality - Lab TA

1989-90 Developmental Psychology - Lab TA
Advanced Social Psychology - Lecture TA

1990-91 Social Psychology - Instructor
Research Methods - Instructor

1991-92 Social Psychology - Instructor
Social Psychology - Instructor

Hollins College

1992-93 Biological Bases of Behavior - Instructor
Psychological Assessment - Instructor