Auditory Temporal Processing Abilities of Autistic Children

Theresa L. Bender
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AUDITORY TEMPORAL PROCESSING ABILITIES
OF AUTISTIC CHILDREN

by
Theresa L. Bender

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
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Department of Speech Pathology and Audiology

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AUDITORY TEMPORAL PROCESSING ABILITIES OF AUTISTIC CHILDREN

Theresa L. Bender, M.A.
Western Michigan University, 1986

Auditory Fusion Thresholds (AFT) of ten autistic individuals between the ages of 5:3 and 14:0 (\(\bar{x} = 9:5\)) were compared with those of 22 normally developing individuals between the ages of 5:0 and 13:2 (\(\bar{x} = 9:5\)). Receptive vocabulary and nonverbal cognitive skills were also assessed for both groups.

Results regarding auditory fusion abilities (Statsgraphics, 1985) were analyzed with nonparametric statistical procedures. No significant differences were found between the AFT scores of the normal and autistic groups. Correlation coefficients that were obtained are:

(a) a moderate negative correlation between AFT scores and nonverbal cognitive scores (normal group) \(r = -.643\),
(b) a low to moderate negative correlation between AFT scores and receptive language scores (normal group) \(r = -.576\),
(c) a low negative correlation between AFT scores and nonverbal cognitive scores (autistic group) \(r = -.381\),
and,
(d) a low positive correlation between AFT scores and receptive language scores (autistic group) \(r = .279\).

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Theresa L. Bender
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CHAPTER I

INTRODUCTION

Since autism was first described by Kanner (1943) it has been broadly agreed that the autistic syndrome is a complex and puzzling disorder. Although autistic persons exhibit marked individual differences, four features are essential to the diagnosis of autism. These are: (a) impaired social development in relating to people, events, and objects; (b) disturbances of speech, language, and cognitive skills; (c) disturbances of developmental rates and/or sequences; and, (d) disturbances of responses to sensory stimuli (Maurer & Damasio, 1982; Ornitz & Ritvo, 1968; Ritvo & Freeman, 1978) (see Appendices A, B, & C). Among these four features, the abnormality of language acquisition is often viewed as a central feature of the autistic syndrome (e.g., Fay & Schuler, 1980; Kanner, 1946; Prizant, 1982b; Rutter, 1978).

However, the question of the basis of the language impairment has not yet been resolved. Cognitive, linguistic and auditory perceptual theories (see the review of literature, Chapter II) have all been proposed. However, the relative influences of the three factors have not been thoroughly investigated. Therefore, this study was designed to investigate the auditory temporal processing capabilities of autistic students in relationship to their cognitive and linguistic capabilities.
Auditory Temporal Processing

The ability to perceive temporal relationships is a critical aspect of auditory perceptual ability. The auditory temporal processing skill studied in this investigation is known as "auditory fusion" (McCroskey, 1984a). The same skill has alternatively been called "auditory temporal acuity" (Irwin, Ball, Kay, Stillman & Rosser, 1985). Auditory fusion is the ability of an individual to determine whether he or she has heard one or two sounds when they occur close together in time.

The *Wichita Auditory Fusion Test* (WAFT) (McCroskey, 1984a), was used as the primary measurement instrument in this study. In developing the test, McCroskey and his colleagues found that individuals who have language disorders also demonstrate auditory fusion thresholds (AFTs) of greater duration (i.e., poorer) than do their normally developing counterparts. Populations that have been studied include individuals who exhibit mental retardation (Murphy, 1982), articulation disorders (Scudder, 1978), and reading and learning disabilities (McCroskey & Kidder, 1980). Such research has shown that the WAFT has discriminative power for differentiating individuals whose deficiencies are related to temporal inefficiency from those who have normal speech and language skills.

Statement of the Problem

The auditory fusion skills of autistic individuals, however, have not been previously investigated. In order to do so, this study was
designed to compare the auditory fusion capabilities of autistic and normally developing individuals between the ages of 5 and 14 years. It was also intended that, by considering multiple combinations of variables, additional information could be obtained about the nature of autism.

Specifically, it was the intent to study the interrelationships of auditory temporal processing ability (as measured by the WAFT), nonverbal cognitive ability (as measured by the Test of Nonverbal Intelligence - TONI) (Brown, Sherbenou & Dollar, 1982), and receptive language ability (as measured by the Peabody Picture Vocabulary Test-Revised - PPVT-R) (Dunn & Dunn, 1981) in autistic, as compared with normally developing children.

Experimental Questions and Statement of Hypotheses

Two major questions were addressed with this study:

1. Do autistic children demonstrate auditory temporal fusion skills that are poorer than those of children developing at a normal rate? It was hypothesized that autistic children would exhibit poorer (i.e., higher) auditory fusion thresholds.

2. Are receptive language and/or nonverbal I.Q. scores related to auditory fusion threshold (AFT) scores? It was hypothesized that both the receptive language and nonverbal I.Q. scores would be negatively related to AFT scores.

A secondary concern was whether auditory fusion threshold scores differed according to sex. It was expected that there would be no significant AFT by sex differences.
CHAPTER II

LITERATURE REVIEW

In this chapter, three major features of the autistic syndrome are reviewed, with a focus on abnormal language patterns. Theories regarding the interrelationships of cognition, language and perception in autism are also reviewed. Finally, information regarding perceptual processing by autistic and normal individuals is considered in greater detail.

Characteristics of Autism

The syndrome of autism is defined and diagnosed by behavioral symptomatology (Fay & Schuler, 1980). The various behavioral symptoms manifested by autistic children fall within four broad categories (see Appendices, A, B, & C). These are: (a) impaired social development in relating to people, events and objects; (b) disturbances of speech, language and cognitive skills; (c) disturbances of developmental rates and/or sequences; and, (d) disturbances of responses to sensory stimuli (Ritvo & Freeman, 1978).

Language and Communication in Autism

Deficits of language and communication are central features of the autistic syndrome (e.g., Kanner, 1946; Prizant, 1983; Rutter, 1978). One of the identifying language patterns of autistic persons is the use of immediate and delayed echolalia (i.e., repetition of...
The term immediate echolalia refers to utterances produced either immediately following, or a brief time after, the production of a model utterance (Prizant & Duchan, 1981). The term delayed echolalia refers to utterances repeated at a significantly later time (Prizant & Rydell, 1984). The production of delayed echolalia involves retrieval of utterances from long term memory, whereas immediate echolalia involves short term or echoic memory (Fay, 1983).

Frequently cited symptoms of aberrant discourse in autism include excessively rigid interactive routines; problems in initiating and terminating interactions; and, deficits in topic maintenance, topic shifting and perception of listener needs (Fay & Schuler, 1980). Such language deficits are well established as central features of the syndrome of autism (e.g., Fay & Schuler, 1980; Prizant, 1982b, 1983). However, the basis of the language impairment continues to be debated.

Theories of Autism

A comprehensive theory of the causes and nature of autism has not been established. Although several theories have been posited to explain the etiology of autistic symptomatology, no substantial evidence supporting any one theory has been presented thus far.

Some theorists have regarded autism as purely psychogenic (Bettleheim, 1967; Tinbergen & Tinbergen, 1983). However, increasing evidence of neurophysiological involvement has shifted the debate regarding etiology to a focus on neurological dysfunction.
Many theories have been proposed regarding the location or nature of the psychoneurological dysfunction in autism. Major categories include cognitive deficit theories (e.g., Rutter, 1978), cognitive-linguistic processing theories (e.g., Prizant, 1983), and sensory information processing theories. The perceptual processing theories can be further subdivided into theories of perceptual-motor processing disturbance (Maurer & Demasio, 1982), perceptual inconstancy (Ornita, 1974), and auditory processing impairment (Wetherby, 1984).

Cognitive Theories

Rutter (1983) postulated that there is a basic cognitive deficit underlying autism. He pointed out that the extent and severity of the cognitive deficit are powerful indicators of probable outcome. He argued that the cognitive deficit is primary to other autistic features and that it may underlie many of the deficits exhibited by autistic children.

Rutter (1983) defined cognition as the mental faculty of knowing. He indicated that cognition is a generic term that includes processes such as perception, attention, learning, memory, judgment and thinking. According to Rutter, the associated abnormalities of language function and usage that are particularly characteristic of the autistic syndrome (e.g., echolalia), are associated with the overall cognitive deficit.
Cognitive-Linguistic Theories

Prizant (1983) defined two modes of cognitive processing that are related specifically to language learning style: (a) a gestalt mode, and (b) an analytic mode. The gestalt mode of cognitive processing is one in which events are remembered or retained with relatively little analysis. It is represented in episodic memory, in which events are remembered only as unanalyzed wholes, and details of the event cannot be recalled.

In contrast, the analytic mode of cognitive processing is one in which experiences or events are analyzed and segmented into meaningful components based on prior experiences. The analytic mode involves the abstracting of information from different, but related, experiences and organizing it conceptually. It is represented in semantic memory with coding of information for recall based on a comparison and contrast of semantic features.

Normal individuals utilize both gestalt and analytic modes of cognitive processing at different times and for different purposes. In adults and older children, the analytic style is believed to be represented symbolically through language (Prizant, 1983). Young children use both analytic and gestalt processing modes, but may adopt one style as primary. Peters (1977) has speculated that those children who use a primarily gestalt style are at a disadvantage because they eventually have to convert to a more analytic style for effective communication skills to be developed.

Prizant (1983) has related the language and communication
patterns of autistic persons (e.g., immediate and delayed echolalia, poor social interactions) to an extreme use of the gestalt mode of cognitive processing. Kanner (1943) has also indicated that the need for sameness or ritualized routines observed among autistic individuals is due to an extreme use of gestalt processing.

**Perceptual Processing Theories**

Learning is a multimodal activity (Lovaas, Schreibman, Koegel & Rehm, 1971) that depends on interrelationships among cognitive, linguistic and perceptual processes. Theorists disagree as to the nature of this triangular relationship, but the existence of the interdependence of the three types of processing has been supported (Prizant, 1983; Rutter, 1978).

The relationship between auditory perceptual processing and linguistic processing is particularly intriguing, since language is acquired primarily through the auditory modality (McCroskey, 1984). Hence, auditory perception and studies of auditory perceptual processing of stimuli, specifically linguistic stimuli, are particularly interesting for their potential to illuminate the nature of the interrelationships. Several such studies are reviewed in the final sections of this chapter.

Perceptual processing theories that have been posited as explanations for the basis of the language deviances demonstrated by autistic persons include the suggestion by Lovaas et al. (1971) that autistic children's cognitive abilities are limited by their tendencies to be "overselective" of sensory stimuli. That is, autistic individuals
appear to be unable to use all available environmental cues for the
processing of information. Rather, they may only be able to attend
to one type of stimulus cue at a time. Hence, abnormal responding
to auditory stimuli may result from the tendency of autistic children
to attend to sensory stimuli from only one modality at a time.

In a related theory, Ornitz and Ritvo (1968) proposed that autistic
children get too little or too much input from the environment and
are unable to maintain perceptual constancy. The failure to maintain
perceptual constancy results in a random overloading or underloading
of the central nervous system. Overloading is evidenced by attention
to inconsequential stimuli; underloading is represented by underres-
ponsiveness to external stimuli. Abnormal responses to stimuli can
result from deficits in systems that mediate sensory input and atten-
tion (Watson, Valenstein & Heilman, 1981). A deficit in the struc-
tures that "gate" the flow of information to the cortex could result
in the odd responses that autistic children exhibit to sensory stimuli
(Maurer & Damasio, 1982).

Alternatively, Hermelin and O'Connor (1970) have suggested that
the unusual responses to sensory stimuli observed in autism may stem
from an inability to encode stimuli meaningfully. They suggested that
this inability is more pronounced with auditory stimuli. Hermelin
and Frith (1971) proposed, further, that the disturbances of responses
to auditory stimuli are directly related to the deviant language
characteristics displayed by autistic individuals.
Auditory Processing in Autism

Echolalia and Auditory Memory

One reason that autism is so puzzling is that many autistic individuals demonstrate paradoxical abilities. For example, in the area of verbal memory, an autistic individual can demonstrate excellent rote memory (e.g., recitation of lists or the alphabet), but be unable to form an original two-word sentence (Fay, 1983; Kanner, 1943; Lord & Baker, 1977). Fay (1983) addressed these paradoxical abilities in his discussion of the relationships between memory, cognitive processing and the production of deviant speech. He suggested that memory systems underlie the deviant language characteristics manifested by autistic persons.

Fay's (1983) longitudinal observations of autistic and non-autistic children showed that the length of echoic utterances produced by the children paralleled their auditory memory capacities. It was also observed that, as normal children mature, their echoic speech decreases along with increases in their memory capacity; whereas autistic children's increasing memory spans are associated with increases in the length of their echoed utterances (Fay, 1969).

Fay (1983) concluded that the auditory memory constraints displayed by autistic persons play a role in their inability to derive meaning from momentarily retained phonetic material. That is, semantic coding of auditory stimuli is hampered by memory constraints. He also pointed out that, at a very early age, all children operate under severe auditory processing constraints because of short term
memory limitations. Fay's (1983) model of ways in which auditory information might be perceived and processed from one memory area to another appears in Figure 1.

![Diagram of Auditory Memory System]

Figure 1. Information Flow Through the Auditory Memory System (adapted from Atkinson & Shiffrin, 1971, and Fay, 1983)

Short term storage is best described as the "working memory," in which verbal items are analyzed, integrated, and coded into auditory linguistic terms (Atkinson & Shiffrin, 1971; Fay, 1983). Overt or covert rehearsal of information is regarded as the means for the transfer of information from short term storage to long term storage. The information held briefly at the sensory register is a literal copy of the auditory input, and is thought to be independent of the central processing mechanisms.

Fay (1983) was concerned primarily with the flow of information into and out of short term storage. However, he stated that it would be erroneous to assume that a faulty short term storage is the basis for the language impairments in autism, because the delayed echolalia that autistic persons frequently exhibit requires the utilization of information in the long term memory bank, which, presumably, has reached it through short term memory.
Craik and Lockhart (1972) also noted that memory is tied to multiple levels of perceptual processing. These levels vary in "depth of processing". Greater depth implies a greater degree of semantic or cognitive analysis. Such processing can enhance retention. Recirculation of information at one level of processing, which is termed "rehearsal," can also facilitate retention.

Because the levels of processing depth are interdependent, a deficit in one part of the system would likely influence other parts (Detterman, 1979). Hence, autistic persons' speech could be conceived of as exhibiting both: (a) a superficial level of perceptual processing (resulting in immediate echolalia), and (b) a potential for long term storage of material via recirculation at this superficial level (resulting in delayed echolalia) (Fay, 1983). Therefore, autistic individuals may demonstrate age appropriate memory spans, but be unable to analyze semantically the information that they retain.

O'Conner and Hermelin (1973) assessed short term memory of autistic subjects utilizing visual presentations. The subjects were required to report numbers either spatially (left to right) or temporally (first to last). Normal subjects preferred the temporal report. Autistic subjects preferred the spatial report. The investigators concluded that the reason the autistic subjects adopted a spatial strategy is because of deficiencies in "subvocal language," which, if intact, would make a sequential temporal coding likely.

Echolalic repetition of speech requires an individual to perform at least a superficial analysis of its phonetic structure. Evidence presented by Penfield and Rasmussen (1950) showed that the primary
receiving strip for auditory stimuli is located in the sylvian margin of the temporal lobe, and that the division of the first temporal convolution is responsible for the analysis and integration of sound (Luria, 1966). Wetherby, Koegel, and Mendel (1981) suggested that inefficiencies of the left temporal lobe are related to autistic persons' tendencies to be echolalic. These findings concur with research suggesting that a "wholistic" or right hemisphere processing preference may be the basis for the language impairment in autism.

**Auditory Temporal Processing by Autistic Individuals**

Perceptual analysis of speech involves recognition of relationships among the three acoustic parameters, frequency, intensity and time (Borden & Harris, 1980; Tallal, Carmazza & Zurif, 1978). The ability to detect frequency and intensity information is routinely evaluated as part of audiological assessments. However, the ability to perceive temporal relationships is rarely assessed. The perception of temporal relationships is an analytic skill that is one of the abilities thought to be specifically impaired in autistic individuals (Prizant, 1983).

Student and Sohmer (1978), in a preliminary study analyzing auditory nerve and brain stem evoked responses, found that autistic subjects manifested longer response latency of the auditory nerve and a longer brain stem transmission time. The authors concluded that their findings indicated the presence of an organic lesion at least in that part of the brain concerned with propagation of auditory...
information. They suggested that the delayed nerve responses may lead to the autistic features, because the affected infant would receive distorted information from the outside world.

Similarly, Tanguay and Edwards (1982) assessed brain stem evoked responses in sixteen autistic children. Their findings concurred with those of Student and Sohmer (1978) and Rosenblum et al. (1980) in suggesting that some autistic children have abnormalities in auditory reception or in central brain stem processing of auditory input.

However, Tanguay and Edwards (1982) interpreted their findings somewhat differently. They posed three possible interpretations: (a) that the brain stem findings have nothing to do with the autistic child's handicap, but are simply another manifestation of a pervasive developmental pathology that affects many parts of the brain; (b) that the brain stem dysfunction leads to distortions of auditory input to the forebrain, resulting in the child's language and cognitive handicaps; and (c) that the distorted auditory and visual input serve as neuropathological agents affecting normal development of neural connections during critical phases of postnatal development.

Wetherby et al. (1981) assessed central auditory function for competing stimuli with autistic subjects. They assessed this function by utilizing the Staggered Spondaic Word Test (SSW) (Katz, 1977a) and the Competing Environmental Sound Test (Katz, 1976). Their results led them to conclude that autistic individuals have cerebral dysfunction of the auditory processing areas.

The SSW test results indicated that the cortical dysfunctions were in the anterior motor speech area (Broca's area) and near the
region of the posterior auditory association area (Wernicke's area). Wetherby et al. (1981) also discussed how these dysfunctions showed striking similarity to transcortical aphasias. Transcortical aphasias are characterized by a preserved ability to repeat (i.e., echo) despite a loss of spontaneous speech fluency (in transcortical motor aphasia), or with severe comprehension problems (in transcortical sensory aphasia), or both. Individuals with transcortical aphasia seem to lack the ability to analyze temporal information in order to derive or encode meaning. Damage to these areas in early infancy, before language acquisition, would have a disruptive effect upon the formation of the neural system underlying language (Luria, 1973). In children, complete development of higher cortical function depends on the integrity of the lower areas.

Prior (1979) noted that frequently cited abilities of autistic persons (e.g., rote visual and auditory memory skills and visuospatial skills) are nonanalytical (Blackstock, 1978; Dawson, Warrenburg & Fuller, 1982; Moscovitch, 1981; Prior & Bradshaw, 1979). These observations have supported the idea that autistic children's deviant language characteristics reflect their "wholistic"/nonanalytical processing preference.

Auditory Temporal Processing by Normal Individuals

For adequate speech perception to occur, the auditory system of a listener must be able to detect specific time intervals and must be able to relate each time interval to the overall rate. Temporal
factors in speech have linguistic significance. Pauses, interruptions in the ongoing acoustic flow of speech, occur between phrases and sentences. Pauses also occur at syllable and phoneme junctures (McCroskey, 1984a).

An individual detects differences in time relationships among different phonemes that enable those phonemes to be distinguished. Temporal distinctions of around 20 milliseconds in voice onset time can make the difference between the perception of such related phonemes as /p/ and /b/ (Borden & Harris, 1980; Eimas, 1975).

Research has also indicated that the duration of interphonemic frequency transitions is essential to accurate auditory perception of temporal sequences. It has been found that the ability to detect auditory sequences is markedly improved as the duration of the transition is extended (Tallal et al., 1978).

**Auditory Temporal Fusion**

The ability to perceive temporal relationships is a critical aspect of auditory perceptual ability. The auditory temporal processing skill studied in this investigation is known as "auditory fusion" (McCroskey, 1984a). The same skill has alternatively been called "auditory temporal acuity" (Irwin, Ball, Kay, Stillman & Rosser, 1985). Auditory fusion threshold (AFT), as defined by McCroskey (1984a), is determined to be the point at which two identical tones, presented with varying interstimulus intervals, are perceived as one tone.

McCroskey and Davis (1976) and Irwin et al. (1985) have both
demonstrated that auditory fusion ability is a skill that develops or matures with age. This means that normally developing subjects are able to achieve "thresholds" of increasingly short interstimulus intervals and still be able to detect auditory stimuli as two separate events up to about age nine or ten. At that time they reach a threshold plateau and do not show significant further changes until their geriatric years. From age 50 on, auditory fusion thresholds again become longer in duration and the variability around the mean increases. McCroskey (1984a) also noted that there were no observed sex differences regarding auditory fusion abilities.

The Wichita Auditory Fusion Test (WAFT) (McCroskey, 1984a) was developed as a means to assess a critical aspect of auditory temporal integrity. Research studies have shown that the WAFT has discriminative power for differentiating individuals whose deficiencies may stem from temporal inefficiency from those who have normal language processing skills (McCroskey, 1984a). The value of utilizing the WAFT with language disordered populations is that it does not utilize linguistically encoded auditory input as stimuli, and it is therefore applicable in attempting to distinguish auditory perceptual processing deficits from linguistic ones.

Summary

The literature suggests that central auditory processing systems of autistic children function differently from those of their normally developing peers. It is possible that components of temporal auditory processing patterns in the autistic child inhibit cognitive growth
and the normal development of language. However, it is also possible that normal neural development is affected during critical developmental phases, resulting in cognitive, linguistic and perceptual deficits. In order to study such relationships further, this study was designed to measure auditory temporal processing abilities of autistic children and to relate those abilities to their receptive language and nonverbal cognitive abilities.
CHAPTER III

METHODS

Four major steps were involved in conducting this study. First, potential participants were identified and parental permission was obtained for including them in the study. Second, participants were screened for their abilities to perform the WAFT. Third, all participants were administered a battery of four tests. Finally, data from participants were statistically analyzed. The specific details for each of these steps are explained below.

Subjects

The design of this study required that two groups be selected: (a) a group of autistic children, and (b) a group of children who were developing at a normal rate. The procedures for selecting participants were approved by the Western Michigan University Human Subjects Institutional Review Board prior to initiating the study. The specific selection criteria and procedures for each group, and the characteristics of participants who participated in the study, are discussed below.

The Autistic Group

The experimental subjects were selected from a program for autistic impaired students at the elementary and secondary school levels in the Grand Rapids Public Schools. This was accomplished
by having school administrators send parent permission letters (see Appendix D) to the families of all students who met the following criteria:

1. At least a moderate level of functioning (i.e., I.Q. of 50 or above.
2. Chronological age range of 6 to 15 years.
3. Nonverbal cognitive ability (i.e., mental age) of approximately 5 to 15 years.
4. Normal hearing according to school records (hearing was also screened as part of the experimental procedure, which is described later).
5. Comprehension of the concept of "one" versus "two" as reported by their teachers.
6. Previous diagnosis as Autistic Impaired by an IEPC.

Sixteen parental permission letters were sent home. Fifteen parents granted permission for their children to participate in this study. However, five of the children for whom permission was obtained were later eliminated as participants when they could not meet the training criteria for the WAFT. The remaining participants included eight male and two female autistic children. They ranged in age from 5:3 (five years, three months) to 14:0 ($\bar{X} = 9:5$). Age and sex data for the autistic group are summarized in Table 1.

The Normally Developing Group

The normally developing children were selected from a private elementary and secondary school in Kalamazoo. Parent permission
Table 1
Age and Sex Data of the Autistic Group

<table>
<thead>
<tr>
<th>Number</th>
<th>Sex</th>
<th>Chronological Age Years</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>F</td>
<td>6:3</td>
<td>75</td>
</tr>
<tr>
<td>A2</td>
<td>M</td>
<td>8:10</td>
<td>106</td>
</tr>
<tr>
<td>A3</td>
<td>M</td>
<td>6:11</td>
<td>83</td>
</tr>
<tr>
<td>A4</td>
<td>M</td>
<td>11:9</td>
<td>141</td>
</tr>
<tr>
<td>A6</td>
<td>M</td>
<td>9:1</td>
<td>109</td>
</tr>
<tr>
<td>A8</td>
<td>M</td>
<td>12:1</td>
<td>145</td>
</tr>
<tr>
<td>A9</td>
<td>M</td>
<td>11:0</td>
<td>132</td>
</tr>
<tr>
<td>A10</td>
<td>M</td>
<td>14:0</td>
<td>168</td>
</tr>
<tr>
<td>A12</td>
<td>M</td>
<td>9:1</td>
<td>109</td>
</tr>
<tr>
<td>A13</td>
<td>F</td>
<td>7:0</td>
<td>84</td>
</tr>
</tbody>
</table>

Letters for potential participants (see Appendix D) were sent to parents of students who met the criteria described below. Using the age distribution guidelines provided by the experimenter, choices were made according to the discretion of the school secretary as to whom should receive letters based on her assessment of families most likely to be cooperative and the following selection criteria:

1. Chronological age range of 5 to 15 years.
2. No history of learning disability, behavioral disorder and/or speech-and language impairment.
3. Comprehension of the concept of "one" versus "two".

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4. Normal hearing (criteria described later) as measured by pure tone air conduction threshold tests.

Thirty-one parents granted permission for their children to participate in this study. Of these, 10 male and 12 female children between the ages of 6:2 and 13:2 (\(\bar{x} = 9:5\)) were utilized as participants (see Table 2). Illness and unavailability at the time of testing eliminated the other children as subjects.

Assessment Tools and Testing Procedures

All participants were assessed with four procedures presented in the same order. In the first session each participant was screened for normal hearing and was tested with the Peabody Picture Vocabulary Test-Revised (PPVT-R) and the Test of Nonverbal Intelligence (TONI). During the second session, the Wichita Auditory Fusion Test (WAFT) was administered. All tests were administered in an environment that protected the participant's privacy, and procedures were implemented to ensure confidentiality of test results.

The first session took approximately 15-25 minutes and the second session took approximately 10-15 minutes. The autistic children tended to require a longer period of time than the normally developing children for both sessions.

Pure Tone Air Conduction Screening

Participation in this study required that each child pass a pure tone air conduction screening test of each ear at 20 dB HL (ANSI, 1970) for 1000 Hz, 2000 Hz and 4000 Hz (ASHA, Committee on Audiometric
### Table 2

Age and Sex Data of the Normally Developing Group

<table>
<thead>
<tr>
<th>Number</th>
<th>Sex</th>
<th>Chronological Age</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Years Months</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>F</td>
<td>9:6</td>
<td>114</td>
</tr>
<tr>
<td>B5</td>
<td>F</td>
<td>10:9</td>
<td>129</td>
</tr>
<tr>
<td>B7</td>
<td>F</td>
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<tr>
<td>B9</td>
<td>F</td>
<td>8:2</td>
<td>98</td>
</tr>
<tr>
<td>B11</td>
<td>F</td>
<td>9:6</td>
<td>114</td>
</tr>
<tr>
<td>B12</td>
<td>F</td>
<td>11:4</td>
<td>136</td>
</tr>
<tr>
<td>B15</td>
<td>F</td>
<td>11:4</td>
<td>136</td>
</tr>
<tr>
<td>B16</td>
<td>F</td>
<td>9:1</td>
<td>109</td>
</tr>
<tr>
<td>B22</td>
<td>F</td>
<td>12:0</td>
<td>144</td>
</tr>
<tr>
<td>B23</td>
<td>F</td>
<td>10:8</td>
<td>128</td>
</tr>
<tr>
<td>B24</td>
<td>F</td>
<td>13:2</td>
<td>158</td>
</tr>
<tr>
<td>B30</td>
<td>F</td>
<td>7:4</td>
<td>88</td>
</tr>
<tr>
<td>B2</td>
<td>M</td>
<td>9:9</td>
<td>117</td>
</tr>
<tr>
<td>B3</td>
<td>M</td>
<td>9:5</td>
<td>113</td>
</tr>
<tr>
<td>B4</td>
<td>M</td>
<td>11:7</td>
<td>139</td>
</tr>
<tr>
<td>B8</td>
<td>M</td>
<td>7:6</td>
<td>90</td>
</tr>
<tr>
<td>B13</td>
<td>M</td>
<td>9:0</td>
<td>108</td>
</tr>
<tr>
<td>B14</td>
<td>M</td>
<td>6:3</td>
<td>75</td>
</tr>
<tr>
<td>B19</td>
<td>M</td>
<td>6:2</td>
<td>74</td>
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<td>6:10</td>
<td>82</td>
</tr>
<tr>
<td>B21</td>
<td>M</td>
<td>5:8</td>
<td>68</td>
</tr>
<tr>
<td>B29</td>
<td>M</td>
<td>11:5</td>
<td>137</td>
</tr>
</tbody>
</table>
Evaluation, 1975). Stimuli were generated by a Maico MA-16 portable audiometer and were delivered to the ears through TDH-39 head phones in MX 41/AR cushions. The children who displayed positive responses at the three frequencies for both ears were utilized as participants. Tests were conducted in an uncontrolled sound field in relatively quiet rooms.

**Peabody Picture Vocabulary Test-Revised**

The Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn & Dunn, 1981) is designed to assess receptive vocabulary skills via a picture pointing task. In this study the PPVT-R was used to operationally define the linguistic ability variable. The test contains 175 items arranged in order of increasing difficulty. Each item has four simple black and white illustrations arranged in a multiple choice format. The subject's task is to select the picture considered to illustrate best the meaning of a stimulus word presented orally by the examiner. For purposes of this study, the PPVT-R was administered according to the standardized instructions described in the manual. Form L was utilized for all subjects.

**Test of Nonverbal Intelligence**

The Test of Nonverbal Intelligence (TONI) (Brown, Sherbenou & Dollar, 1982) is designed to measure nonverbal cognitive abilities. It does not require language comprehension abilities. The test includes a variety of abstract problem solving tasks, increasing in complexity and difficulty. The administration format of the TONI
does not require the subject to read, write, or make oral responses. For purposes of this study, the TONI was administered individually and according to the instructions described in the manual. Form A was utilized for all subjects. TONI scores were used to operationally define the cognitive ability variable.

**Wichita Auditory Fusion Test**

A modified version of the Wichita Auditory Fusion Test (WAFT) (McCroskey, 1984a) was the primary experimental instrument used in this study. It was used to assess each participant's auditory temporal perceptual abilities in terms of an auditory fusion threshold (AFT). As defined by McCroskey (1984a), AFT is determined to be the interstimulus interval at which two identical tones, presented with gradually ascending and descending interstimulus intervals, are perceived as one tone.

The published version of the WAFT was adapted for this study (as described below), with permission of the author and publisher. The adapted test consisted of a specifically constructed training tape, the screening tape from the original WAFT, a modified expanded test tape (tape A-3), and a modified short test tape (tape A-4). The training tape, tape A-3 and tape A-4 were dubbed from original tapes included in the test kit for use in this study using Audiotronics (148 B) and Sony (TCM 787) tape recorders. The only modification of tapes A-3 and A-4 was that only the stimuli presented at 1000 Hz and 4000 Hz were dubbed. Test stimuli at 250 Hz and 500 Hz were not used in this study in order to shorten the task and to
present stimuli that were less likely to be masked by ambient noise in the test rooms.

The experimental administration of the WAFT in this study involved a three-step procedure. First, all participants were trained utilizing the training tape. Second, all participants were screened with the screening tape. Finally, all participants were administered either the short test or the expanded test depending on the results of the screening tape. All tapes were presented at 74 dB SPL (calibrated with a Brüel & Kjær Sound Level Meter and a Brüel & Kjær Artificial Ear type 4152) with an audiotronics 148 B tape recorder. The signal was routed through the internal speaker for the administration of the training tape. The experimental tapes were administered through TDH-39 headphones with MX 41/AR cushions. The specific tapes, tests and procedures are described below.

**Training**

The training tape was specially constructed for this study because of a concern that the autistic participants might have difficulty learning the response procedure for indicating whether they had heard one or two stimuli. On the training tape, the stimuli were recorded at 250 Hz so as to avoid repetition of the experimental stimuli from the test tape.

The tape included a 500 Hz calibration tone and 10 sets of 10-paired tones at 250 Hz with extreme values of long and short silent intervals between each pair. The silent intervals were measured in milliseconds (ms). The stimuli dubbed from the original screening
tape were those with the maximum and the minimum millisecond inter-
stimulus intervals. These extremes were chosen for training to avoid
using threshold level interstimulus intervals to avoid using thresh-
hold level interstimulus intervals when attempting to ensure that
subjects understood the task. The choices of stimuli included those
with interstimulus intervals of 0 ms, 2 ms, 30 ms, 40 ms, and 200 ms.
The order of presentation of stimuli on the training tape was ran-
domized.

The training and testing procedures were accomplished in a single
session, using controlled reinforcement schedules, verbal instructions
and motoric demonstrations. Both social reinforcers and edible rein-
forcers (M&Ms) were available for the training sessions. The social
reinforcers alone were used for the normally developing participants
and some members of the autistic group. Both types of reinforcers
were used for the autistic participants who demonstrated attending
difficulties.

During the first phase of the training procedure the examiner
told the subjects that they were going to hear some sounds and that
they were to listen and watch the examiner. The examiner verbally
modeled the expected behavior for the first five tones in set number
one on the training tape. She said, "Listen, I hear 2 beeps," and
touched the card with two dots on it. "That's correct, so I get an
M&M." She placed an M&M in her cup. Or she said, "good" and lis-
tened for the next stimulus. The examiner nonverbally modeled the
expected behaviors for the last 5 tones of set number one. She
touched the correct card after listening to the stimulus and
reinforced herself 100% of the time accordingly (i.e., with an M&M or by saying, "good").

The participant was reinforced 100% of the time for correct responses throughout set number two. If the participant responded incorrectly the examiner said, "No, it's this," while touching the correct card. A fifty percent reinforcement schedule was utilized during administration of set number three. Once the participant reached the criterion of six consecutive correct responses, the screening tape was administered.

Five of the original fifteen autistic children for whom parental permission was obtained were eliminated from the study during the training process. One student was unable to tolerate wearing the headphones. Another student was eliminated because of irregular responses during the pure tone air conduction screening. A third subject was eliminated because of inability to complete the four testing procedures before moving. A fourth subject did not pass the training session. The fifth student was eliminated because of irregular responses during the WAFT screening. The student had passed the training session, but responded "one" throughout the entire WAFT screening session. It is possible that these last two students were unable to perform the task because the 250 Hz frequency of the training stimuli was masked by ambient room noise, because of poor cognitive abilities, or because of extreme perceptual difficulties. The 10 autistic children who did serve as subjects did demonstrate clear ability to perform the task.
WAFT Screening and Testing Procedures

Following training procedures, the original screening tape from the test kit was utilized for this study. The screening tape includes paired pure tones with variable silent intervals between each pair. The interstimulus intervals gradually increase for the first nine items and gradually decrease for the following nine items. The interstimulus intervals vary from 0 ms to 300 ms for the 18 paired pure tones. The screening tape does not yield an auditory fusion threshold (AFT). Rather, the results of the screening tape are used to determine which test tape (i.e., tape A-3 or A-4) should be administered.

The only difference between the two test tapes is in the range of interstimulus intervals tested. The short test (A-4) includes silent interstimulus intervals that range from 0 ms to 40 ms in an ascending and descending order, and the expanded test (A-3) includes silent interstimulus intervals that range from 40 ms to 300 ms in ascending and descending order. All of the children in both groups in this study were able to perform well enough to use tape A-3, with the exception of one student in the normal group, who needed tape A-4. This individual was later disqualified as a normal subject because of the abnormal level of his AFT total score compared with norms reported by McCroskey and Davis (1976).
CHAPTER IV

RESULTS

It was the purpose of this study to investigate the auditory temporal processing abilities of autistic children and the relationship of these abilities to autistic children's nonverbal cognitive and receptive language abilities compared to those of normally developing children. In this chapter the results of testing and statistical analysis are reviewed.

The dependent variable was auditory fusion threshold (AFT) scores. Receptive language test scores and nonverbal cognitive test scores were also gathered for performing correlational analyses. The independent variables were group (autistic and normal) and sex.

This study was originally designed to be analyzed utilizing an analysis of covariance (ANCOVA), with chronological age, receptive language scores, and nonverbal cognitive scores as covariates. However, preliminary analysis of the results showed that the data did not meet the assumptions of ANCOVA. That is, chronological age, nonverbal I.Q. scores, and WAFT scores were not normally distributed, and they exhibited unequal variability across groups. In addition, correlations between chronological age and AFT scores, and between I.Q. and AFT scores were not equal across groups. These findings combined with relatively small number of individuals in the autistic group, led to the decision that ANCOVA was not appropriate for use in this study.
Several nonparametric procedures were therefore used instead. Auditory Fusion Thresholds (AFT) of the autistic group were compared with those of the normal group utilizing the Mann Whitney Wilcoxon Test (Statsgraphics, 1985). AFT scores were also compared according to sex utilizing the Kruskal-Wallis Test. Post hoc correlational analyses were completed using the Spearman Rank Order Test.

Summarized Raw Data

Descriptive statistics for the data compiled from testing are summarized in Table 3. The complete set of raw data are presented in Appendix E. Median scores were judged to be more reliable measures of central tendency than mean scores because of asymmetric distribution and the presence of extreme outlying scores for both groups.

Analysis of Differences by Group and Sex

Test of Group Differences

The primary experimental question of this study was whether auditory fusion abilities of autistic individuals were different from those of normal individuals. In order to answer this question, the Mann Whitney Test (Statsgraphics, 1985) was computed comparing ranks of the AFT total scores of the autistic group with ranks of the AFT total scores of the normal group. The test produced a nonsignificant difference ($z = 1.16, P > .05$). This means that the autistic and normal groups did not display auditory fusion abilities significantly different from each other.
Table 3
Summarized Raw Data

<table>
<thead>
<tr>
<th>Test</th>
<th>Unit of Measure</th>
<th>Median</th>
<th>X</th>
<th>S.D.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFT</td>
<td>ms</td>
<td>4.05</td>
<td>4.77</td>
<td>3.13</td>
<td>.5-11.3</td>
</tr>
<tr>
<td>PPVT</td>
<td>months</td>
<td>56.50</td>
<td>66.30</td>
<td>26.00</td>
<td>48-130</td>
</tr>
<tr>
<td>TONI</td>
<td>I.Q.</td>
<td>88.50</td>
<td>85.60</td>
<td>20.59</td>
<td>60-118</td>
</tr>
<tr>
<td>Age</td>
<td>Yr:Mo</td>
<td>9:0</td>
<td>9:5</td>
<td></td>
<td>6:3-14:0</td>
</tr>
</tbody>
</table>

Control Group (N=22)

<table>
<thead>
<tr>
<th>Test</th>
<th>Unit of Measure</th>
<th>Median</th>
<th>X</th>
<th>S.D.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFT</td>
<td>ms</td>
<td>5.50</td>
<td>7.58</td>
<td>6.44</td>
<td>2.0-28.8</td>
</tr>
<tr>
<td>PPVT</td>
<td>months</td>
<td>133.50</td>
<td>136.2</td>
<td>49.67</td>
<td>78-290</td>
</tr>
<tr>
<td>TONI</td>
<td>I.Q.</td>
<td>112.00</td>
<td>114.86</td>
<td>20.38</td>
<td>70-129</td>
</tr>
<tr>
<td>Age</td>
<td>Yr:Mo</td>
<td>9:5</td>
<td>9:5</td>
<td></td>
<td>6:2-13:2</td>
</tr>
</tbody>
</table>

The Kruskal-Wallis Test (Statsgraphics, 1985) was used to measure possible differences in AFT scores according to sex (4 group X sex subgroups). This procedure yielded a probability level of .57 indicating no relationship between AFT scores and sex.

Correlational Analyses

Additional post hoc questions concerned relationships among the three variables, auditory fusion thresholds (AFTs), nonverbal I.Q. scores, and receptive language scores. The Spearman Rank Order Test was used to compute correlation coefficients for receptive language.
Correlation of PPVT and AFT Scores

Analysis of receptive language scores and total AFT scores for the autistic group yielded a correlation coefficient of $r = 0.279$. This means that the expected negative correlation between receptive language scores and AFT scores for the autistic group did not occur. That is, there was no tendency for AFTs of longer duration (i.e., "poorer" scores) to be associated with lower vocabulary scores. In fact, the positive, but low, correlation coefficient indicated a weak trend for "poorer" AFT scores to be associated with receptive vocabulary scores that were somewhat higher.

Spearman Rank Order analysis of receptive language scores and total AFT scores for the normal group yielded a correlation coefficient of $r = -0.576$. Thus, the normal group demonstrated the expected negative relationship between receptive language skills and auditory fusion skills. That is, there was a low to moderate tendency for AFTs of shorter duration (i.e., "better" scores) to be associated with receptive language scores that were higher.

Correlation of TONI and AFT Scores

Spearman Rank Order analysis of TONI (nonverbal I.Q.) scores and AFT total scores for the autistic group yielded a correlation coefficient of $r = -0.381$. This means that there was a weak trend toward a negative relationship between nonverbal I.Q. and AFT abilities among
the autistic participants, with a tendency for AFTs of shorter duration (i.e., "better" scores) to be associated with higher nonverbal I.Q. scores.

Spearman Rank Order analysis of nonverbal I.Q. scores and total AFT scores for the normal group yielded a correlation coefficient of \( r = -0.643 \). This indicates that there was a moderate negative relationship between nonverbal I.Q. and AFT abilities for the control group. That is, there was a moderate tendency for AFTs of shorter duration (i.e., "better" scores) to be associated with higher nonverbal I.Q. scores.

AFT scores of the autistic group are plotted according to age in Figure 2. AFT scores of the normal group are plotted according to age in Figure 3. As illustrated with these figures, neither group displayed a predictable relationship between AFT scores and age. The normally developing group, however, did show a slightly stronger relationship than did the autistic group, especially if the outlying scores are ignored. Normative data gathered by McCroskey and Davis (1976), for 448 individuals are included in Figure 3 so as to facilitate a comparison of the normal group of this study with previously obtained normative data. This trend for AFT scores to improve with age is consistent with the results of the McCroskey and Davis (1976) study. The autistic group, however, demonstrated variable scores that did not yield a clear trend. Some participants' AFT scores were better than the norm; some participants' AFT scores were poorer than the norm; and some were within normal limits.
Figure 2. AFT Scores (in ms) by Chronological Age for the Autistic Group. This graph was computer generated using Statsgraphics (1985).

Figure 3. AFT Scores (in ms) for Normal Groups. Key: • = normal group from this study;  ≠ normative data from McCroskey & Davis (1976). This graph was computer generated using Statsgraphics (1985).
Summary

To summarize the results of this study, no significant difference was found between the auditory fusion abilities of the autistic and the normal groups. The mean and median AFT scores of the autistic group were slightly better than the mean and median AFT scores of the normal group, but not significantly better. Neither were auditory fusion abilities significantly different according to sex.

Correlation analysis of the receptive language and auditory fusion threshold scores of the individuals in the autistic group demonstrated little or no relationship. The normal group demonstrated a weak tendency for better auditory fusion abilities to be associated with better receptive language abilities and a moderate tendency for better auditory fusion abilities to be associated with better nonverbal cognitive abilities. The autistic group demonstrated a weak tendency for better auditory fusion abilities to be associated with better nonverbal cognitive abilities.
CHAPTER V

DISCUSSION

Auditory Temporal Processing Abilities

Auditory Fusion Abilities

In answer to the primary experimental question, it was found that the autistic and normal groups did not display significantly different auditory fusion abilities. Although, the median and mean AFT scores of the autistic group were slightly lower (i.e., better than the median and mean AFT scores of the normal group), they were not significantly better. It was notable that a few individuals in both groups demonstrated extreme scores. Such outlying led to skewed distributions that prohibited the use of parametric statistics.

Interestingly, the two most extreme scores were earned by members of the normal group. One "normal" participant received a total AFT score of 52.2 milliseconds (ms). His test results were not utilized in the statistical analyses, however, because they were not considered to be within the normal range. One consideration for future investigation based on this finding is that students may be less likely to have been referred to special educators for assessment of possible auditory processing difficulties if they attend private schools, and it may be inappropriate to use such a criterion as an indicator of normal development.

The fact that the autistic participants did not display auditory
temporal processing deficits of the type demonstrated by excessive high AFT scores has implications for understanding differences between autistic children and other language impaired children. Former studies utilizing the Wichita Auditory Fusion Test (WAFT) have shown that other language impaired children demonstrate higher than normal AFT scores, suggesting the presence of auditory temporal processing deficits (McCroskey & Kidder, 1980; Murphy, 1982; Scudder, 1978). The results of this study for the autistic group, however, actually showed no tendency for better AFT scores to be associated with better receptive verbal ability (PPVT) scores. In fact the correlation coefficient that did result from this analysis showed, if anything, a weak positive relationship. One interpretation of this finding could be that autistic children exhibit an "overselective" (Lovaas et al., 1971) processing system which could contribute to a language deviance, rather than a language delay. For such children, "better" AFT scores might be symptomatic of other aspects of the autistic syndrome.

The Overselective Theory

The theory of overselectivity holds that autistic children are only able to attend to one stimulus cue at a time (see Chapter 11) (Lovaas et al., 1971). The testing procedures for the WAFT requires the individuals to attend to paired tonal stimuli and to produce a response. It is possible that the nature of the test stimuli served to encourage the "overselective" tendencies of autistic children. The finding that the autistic children in this study performed differently from other language impaired children in former studies
supports the contention that the neurolinguistic bases of autistic children's language impairments are different from those of other language impaired children. That is, whereas other language impaired children often show associated auditory temporal processing deficits (McCroskey, 1984; Tallal et al., 1978) autistic children's language impairments are not correlated with auditory temporal processing deficits, as measured with the WAFT. In fact, especially in some individual cases, they appear to be associated with enhanced or better than normal auditory temporal fusion abilities.

**Language Deviance Versus Language Delay**

Many autistic children demonstrate echolalic speech that is comparable to that exhibited by adults with specific types of aphasia. As discussed in Chapter II, similarities exist in the language impairments of autistic individuals and those with transcortical aphasia (Wetherby et al., 1981). The ability to encode auditory stimuli meaningfully is lacking in both disorders. Autistic persons and persons with transcortical aphasia have both been found to demonstrate dysfunctions in areas adjacent to Broca's (motor) and/or Wernicke's (association) areas (Wetherby, 1981). If the auditory stimuli received by autistic individuals and adults with aphasia are not able to leave the arcuate fasciculus, they would be unable to be processed analytically in areas of higher cortical functions. These deviances could account for the manifestation of immediate and delayed echolalia in autistic persons having normal AFT capabilities.

Craik and Lockhart (1972) (see Chapter II) proposed that the
echolalia stems from a superficial level of processing and recirculation of this information at a superficial level. This proposition concurs with the idea that the received stimuli are unable to leave the arcuate fasciculus.

Interestingly, four autistic subjects in this study demonstrated immediate and/or delayed echolalia of stimulus words with the PPVT and of tonal stimuli during the WAFT presentation (i.e., they said "beep, beep" or "beep" after hearing a stimulus pair (see Appendix E). The other six subjects did not display stimulus echolalia during testing. The mean and median AFT scores (mean = 3.28 ms; median = 3.25 ms; range = 2.3 ms - 4.3 ms) for the four subjects who echoed were better (i.e., lower) than the mean and median scores (mean = 5.77 ms; median = 5.25 ms; range = .5 ms - 11.3 ms) for the six subjects who did not use echoic speech.

Although these results were not submitted to statistical analysis because of the small number of subjects in each group, they suggest the need for further investigation of the possibility that superficial, but precise, perceptual processing is associated with a tendency to echo what is said rather than to be able to submit auditory stimuli to deeper instantaneous analysis. On the other hand, stimulus echoing may merely represent an effective cognitive processing strategy. However, the only child in the normal group who demonstrated stimulus echoing was the one who earned the extremely high AFT score. Further study would be helpful to determine whether a relationship exists between inappropriate echolalia in conversational interaction and AFT scores.
Sex and Auditory Fusion Abilities

No significant differences occurred between the auditory fusion abilities of male participants and female participants in this study. However, related to the well-established male:female sex ratio of 4:1 among autistic individuals (Fay & Schuler, 1980), only two female autistic children were available for testing. The finding of no sex differences in this study did concur with those from previous normative studies which utilized the WAFT to measure auditory temporal processing (McCroskey, 1984a).

Receptive Language and Nonverbal Cognitive Abilities

Receptive Language and Auditory Fusion Abilities

For the normal subjects in this study, a low to moderate negative relationship appeared between receptive language scores and AFT scores. That is, there was a moderate tendency for better (i.e., lower) AFT scores to be associated with higher receptive language scores. This negative correlation is the expected one, because auditory temporal processing skills have been shown to mature with age (Fay, 1983; Irwin et al., 1985; McCroskey & Davis, 1976) as does language. Normally developing individuals are expected, by definition, to demonstrate commensurate levels of cognitive, verbal and auditory processing ability. However, the autistic group showed no relationship of AFT scores and receptive language scores. It had been anticipated (see Chapter I) that poor AFT scores would be
associated with poorer receptive language scores. However, autistic participants, if anything, demonstrated a weak tendency for AFT scores of longer duration (i.e., poorer ones) to be associated with better receptive language scores. That is, poorer auditory fusion abilities did not lead to a prediction of poorer receptive language scores.

In discussing implications of this study regarding language ability, it should be remembered that the Peabody Picture Vocabulary Test is a receptive vocabulary test of single words only, not of connected speech used for communication purposes. However, in a related study in which autistic children's comprehension of time expanded connected speech was investigated (Lehr & Nelson, 1985), it was also found that time (in the form of electronically controlled speaking rate) was not a significant factor in determining language comprehension of sentences. This was interpreted to be an indication that deficits of auditory linguistic processing are not as critical a factor in the communication problems of autistic children as sometimes imagined.

Lehr and Nelson (1985) raised the question of possible temporal distortion due to electronic control, in their study, since it involved manipulation of temporal acoustic relationships in order to expand speech. It was suggested that the slowest speaking rate did not show the expected facilitative effect on comprehension because the autistic participants might have been negatively affected by the perceptual distortion in the extreme (very slow) rates. The results of the present study demonstrated that autistic children were
sensitive to the perception of temporal information in the form of
silent intervals between acoustic stimuli (although they did not
differ significantly from normal children in this respect) and that
those children who had better temporal perception skills showed a
weak tendency to have poorer receptive vocabulary skills. The
possibility that a high level of attention to the surface level tem­
poral characteristics imposed by time expanded speech might cancel out
possible facilitative effects of more processing time still cannot
be ruled out.

Nonverbal I.Q. and Auditory Fusion
Abilities

In this study, autistic and normal participants both demonstrated
a low negative correlation between AFT scores and nonverbal I.Q. (TONI)
scores. Rutter (1983) postulated that the abnormalities of language
function and usage demonstrated by autistic individuals are associated
with an overall cognitive deficit (see Chapter II). Such a relation­
ship can be illustrated by considering the results for some individual
participants in this study. For example, participant number A4, in
this study, had the highest nonverbal I.Q. of all the autistic partici­
pants. He also had the best receptive language and lowest (i.e.,
best) AFT scores of the group. Participant number A8 had the lowest
nonverbal I.Q. score, one of the lowest receptive language scores
and the highest (i.e., poorest) AFT score. These participants were
within one chronological year of each other (see Appendix E).

Another interpretation of these results relates to Prizant's
(1983) view of cognitive-linguistic processing (see Chapter II).
The inability on the part of the autistic participants to benefit from increased time in the Lehr and Nelson (1985) study was interpreted as possibly suggesting an extreme use of the gestalt cognitive processing mode. However, as discussed earlier, better auditory temporal processing skills (an analytic skill) may, in fact, lead to poorer receptive language skills, although wide individual differences (as noted above) can be expected.

An extreme use of the gestalt cognitive processing mode could result in many of the aberrant behaviors that autistic children exhibit (Prizant, 1983). These deficiencies would be seen in all areas, including auditory perception, receptive language, and cognition. It is possible that autistic children are extremely dependent on the gestalt cognitive processing mode. The low to moderate correlation between nonverbal I.Q. and AFT scores, that appeared in this study, supports this contention. However, it is also possible that the autistic child's language deviances stem from "overly" precise auditory temporal perceptual skills. These "advanced" temporal perceptual skills may be a component of a syndrome characterized by extreme use of the gestalt cognitive processing mode.

Clinical Implications

Although the language abnormalities of autistic individuals do not appear to stem from auditory temporal processing "deficits" in the traditional sense, teachers, parents, and clinicians need to
be aware of rate and complexity variables in their speech with autistic children. Autistic children may be overly sensitive to surface level auditory information, and this oversensitivity may distract them from obtaining meaning.

Intervention for autistic children should concentrate on language development and language processing, but the selection of different methods of language instruction should depend on the individual student's cognitive, linguistic, and auditory temporal perceptual abilities. Intervention techniques should be designed to encourage the interaction of the gestalt and analytic modes of cognitive processing.

Recommendations for Future Research

Problems in the design of the current study might be addressed in future studies by using larger subject groups and better controls for determining 'normalcy' in the control group. Such replication could examine further the correlational trends identified in this study to determine if they are confirmed and possibly stronger than indicated here. Future studies of the relationship of cognition, perception, and language in autism might also use different kinds of experimental measures.

Additional studies are also needed to extend the results of this one. For example, future comparative research could compare the auditory fusion abilities of echolalic autistic children and non-echolalic autistic children. A direct study comparing the abilities of autistic impaired children with those of other
language impaired children might also be conducted. In addition, further research could compare the abilities of adults with acquired brain lesions with those of autistic children.

Conclusions

This study was designed to explore auditory fusion abilities and their relationship to nonverbal cognitive abilities and receptive language abilities. The conclusions that can be drawn from this study are as follows:

1. Autistic children do not exhibit auditory fusion abilities that are significantly different from those of normal children.
2. Auditory fusion abilities are not significantly different for female and male children.

Implications of these conclusions for broader interpretation are that:

1. Receptive language scores of autistic impaired children are not correlated with their auditory fusion threshold scores.
2. Nonverbal cognitive scores of autistic children are weakly correlated with auditory fusion threshold scores.
3. Autistic impaired children do not show the same association between AFT and language scores as other language impaired groups have shown in former studies.
APPENDIX A

BEHAVIORAL SYMPTOMS OF AUTISM
Behavioral Symptoms of Autism  
(Auffrey, R., 1983)

1. Disturbances of speech, language and cognitive abilities:

   Behavioral Symptoms

   - Autism
   - Echolalia
   - Inappropriate timing and content
   - Flat affect, atonal, arhythmic speech
   - Hyperactive speech
   - Immature syntax
   - Absence of gestures
   - Non-communicative speech
   - Delayed onset
   - Perseverative speech
   - Pronoun reversals

2. Disturbances of the capacity of relating to people, events and objects:

   Behavioral Symptoms

   - Absence of social smile
   - Withdrawn from people
   - Limpness or stiffness when held
   - Avoids eye contact
   - No friendships
   - Does not attend to social stimuli
   - Not responsive to others expressions/feelings
   - Resists being touched
   - Does not imitate other children at play
   - Often frightened or anxious
   - "Looks through people"
   - Inappropriate attachment to objects

3. Disturbances of developmental rates and/or sequences:

   Behavioral Symptoms

   - Gross motor milestones normal but fine motor milestones are delayed
   - Delay in speech
   - Not toilet trained
   - Regressions in motoric skills, e.g., stops walking, talking
   - Delay in social adaptive and cognitive milestones

4. Disturbances of responses to sensory stimuli:

   Behavioral Symptoms

   - Visual
     - Close scrutiny of visual details
     - Non-use of eye contact

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Prolonged staring
Flicking hand in front of eyes
Attention to changing levels of illumination
Over/under response to visual cues
Ritualistic arrangement of objects

**Auditory**
Close attention to self-induced sounds
Non-response to varying sound levels
Over-response to varying sounds
Seems not to hear

**Tactile**
Hypo-hyper response to touch
Hypo-Hyper response to temperature
Prolonged rubbing of surfaces
Sensitivity to food textures and bizarre food preferences
No response to painful stimuli
Licking inedibles
Self-injurious behaviors

**Olfactory**
Smells objects/repetitive sniffing
Very specific food preferences
Licking inedibles
Bizzare food preferences

**Vestibular**
Over/under response to gravity stimuli
Whirling without dizziness
Preoccupation with spinning objects

**Proprioceptives**
Whirls self for long periods of time
Rocks self for long periods of time
Lunging/darting about
Toe walking/prancing gait
Handflapping
APPENDIX B

SUBCLUSTERS OF OBSERVABLE BEHAVIORS
Subclusters of Observable Behaviors
(Ornitz & Ritvo, 1968)

Disturbances of Perception

Heightened Awareness of Sensory Stimuli:
  - Auditory
  - Visual
  - Tactile
  - Olfactory and Gustatory
  - Vestibular

Heightened Sensitivity and Irritability:
  - Auditory
  - Visual
  - Tactile
  - Olfactory and Gustatory
  - Vestibular

Nonresponsiveness:
  - Auditory
  - Visual
  - Tactile
  - Pain

Disturbances of Motor Behavior

Motor Behaviors Apparently Associated with Sensory Input:
  - Auditory
  - Visual
  - Tactile
  - Vestibular
  - Propriocaptive

Miscellaneous Motor Phenomena:
  - e.g., toe walking

Disturbances of Relating
  - e.g., poor eye contact, delayed or absent social smile

Disturbances of Language
  - e.g., failure to develop speech, echolalic speech

Disturbances of Development Rate

  The rate of development may be disturbed, leading to discontinuities in the normal sequence.
APPENDIX C

BEHAVIORAL SYMPTOMATOLOGY
The following list is a summary of Kanner's (1943) original description of the behavioral symptomatology of autism.

1. Withdrawal from, or failure to become involved with, reality; in particular failure to form a normal relationship with people (i.e., a detachment from human relationships).

2. Failure to acquire or to maintain or improve on speech already learned, or to use what speech has been acquired for communication.

3. Pathological resistance to change, which may be shown by:
   a. Insistence on observance of rituals in the patient's own behavior or in those around him.
   b. Pathological attachment to the same surroundings, equipment, toys and people (even though the relationship with the person may be purely mechanical and emotionally empty).
   c. Excessive preoccupation with particular objects or certain characteristics of them, without regard for their accepted functions.
   d. Severe anger or terror or excitement, or increased withdrawal when the sameness of the environment is threatened (e.g., by the introduction of strangers into the child's environment).

4. Fascination for objects.

5. Good cognitive potentialities with demonstrated islets of higher or nearly normal or exceptional intellectual functions or skills in some.
Dear Parents:

I am writing to request your help with my Master's Thesis research project. My project will compare the listening abilities of children who are "autistic impaired" and children who are progressing at a normal rate.

If you give permission for your child to participate in this study, a series of tests will be administered to him/her in a room at his/her school. All sessions will be pre-scheduled with individual teachers so as to be minimally disruptive. There will be no charge for any of the testing procedures. The experimental activities are as follows:

First Session

2. A test of nonverbal abilities.
3. A test of receptive vocabulary.
Approximate Total Time: 1 - 1½ hours

Second Session

1. A test of auditory perception. This test will require your child to listen to a series of "beeps" and tell whether he/she heard "one" or "two" "beep(s)."
Approximate Total Time: 40 - 50 minutes.

These activities will be presented at a normal loudness level. All children will be allowed to withdraw from the study at any time without penalty. A paper will be written when the study is completed. The identity of your child will be kept confidential throughout the study and when the results are reported.

If you have any questions contact [blank] from your child's school, or call me at 1-616-382-6143 or my faculty advisor at 1-616-383-0963.
Please return the attached permission form to the school by ________________. Thank you for your time, cooperation and consideration.

Sincerely,

Theresa L. Bender
Graduate Student

Nickola W. Nelson, Ph.D., CCC/SP
Faculty Advisor
I __________________________________ have read and understand the attached letter. I understand that I have the right to withdraw from this study at any time. I also understand that this research project is being done by a graduate student with appropriate supervision.

As legal guardian of ______________________,

/ / I give my permission for ______________________to participate in this study.

/ / I do NOT give my permission ______________________to participate in this study.

/ / I would like more information.

__________________________________________
Signature

Please Print:

__________________________________________
Guardian's Name(s)

__________________________________________ / /
Child's Name Birthdate School Program

__________________________________________
Address City Zip

__________________________________________
Phone

Theresa L. Bender
Graduate Student

Nickola W. Nelson, Ph.D., CCC/SP
Faculty Advisor

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If you give permission for your child to participate in this study, a series of tests will be administered to him/her in a room at his/her school. All sessions will be prescheduled with individual teachers so as to be minimally disruptive. This testing may take additional sessions for some children. There will be no charge for any of the testing procedures. The experimental activities are as follows:

**First Session**

2. A test of nonverbal abilities.
3. A test of receptive vocabulary.

Approximate Total Time: 1½ - 2 hours

**Second Session**

1. A test of auditory perception. This test will require your child to listen to a series of "beeps" and tell whether he/she heard "one" or "two" "beep(s)."

Approximate Total Time: 40 - 50 minutes

These tests will be presented at a normal loudness level. All children will be allowed to withdraw from the study at any time without penalty. A paper will be written when the study is completed. The identity of your child will be kept confidential throughout the study and when the results are reported.
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_________________________  
Signature

Please Print:

______________________________  
Guardian's Name(s)

______________________________  / /  
Child's Name  Birthdate  School Program

______________________________  
Address  City  Zip

______________________________  
Phone

______________________________  
Theresa L. Bender  
Graduate Student

Nickola W. Nelson, Ph.D., CCC/SP  
Faculty Advisor
APPENDIX E

RAW DATA
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**Key:**

- Group 1 = Autistic subjects
- Group 2 = Control subjects
- * = Subjects who echoed during testing
- C.A. = Chronological age in years:months
- C.A. months = Chronological age in months
- PPVT months = PPVT language age in months
- PPVT age equivalent = PPVT language age in years:months

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### Key:
- **Group 1** = Autistic subjects
- **Group 2** = Control subjects
- * = Subjects who echoed during testing
- **TONI quotient** = Nonverbal I.Q.
- **AFT 1000** = AFT score at 1000 Hz
- **AFT 4000** = AFT score at 4000 Hz
- **Total AFT** = Mean AFT of 1000 Hz and 4000 Hz

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