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AUDITORY DISCRIMINATION OF FOUR AND NINE YEAR OLDS AS A FUNCTION OF STIMULUS CONTEXT

By

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A.B., Gonzaga University, 1973

Presented in partial fulfillment of
the requirements for the degree of

Master of Arts

UNIVERSITY OF MONTANA

1975

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

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A discrimination test was devised using the same twenty-four monosyllabic words in three different contexts: 1) in isolation; 2) preceded by a tone; 3) preceded by a carrier phrase. The lists were presented in a counterbalanced order to thirty four-year olds and thirty nine-year olds.

The findings indicated that performance of the nine year olds was significantly better than that of the four year olds. Both age groups performed significantly better on the word in isolation task than on the word in the carrier phrase. There was no significant difference between performance on the word in the carrier phrase and the word preceded by a tone. In addition, both groups of children performed significantly better on the third-presented list than on either the first or the second-presented lists, regardless of stimulus context.

It was concluded that usage of the carrier phrase in assessing children's auditory discrimination should be re-evaluated. The results of this study also indicated that four year old children are capable of performing a verbal, open-set discrimination task.

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CHAPTER I

INTRODUCTION

Auditory discrimination has been defined as the "ability to distinguish between closely related speech sounds" (Weiner, 1967). Clinically, the assessment of auditory discrimination is important in determining how well the auditory system is able to handle features of speech, including such aspects as rate, rhythm and duration, as well as frequency and intensity--a process of formation and integration (Hirsh, 1952). Fry (1964) stated that it is difficult to predict how the auditory system will respond to speech sounds, which is a central rather than a peripheral phenomenon, from knowledge of its response to pure tones. There are, however, many problems involved in the testing of auditory discrimination, one of the most basic being the nature of the measuring device itself (Weiner, 1967). The study of discrimination abilities, as with other perceptual abilities, inherently involves inference. The measuring instrument must intervene between the discrimination behavior and the overt indication of this behavior (which is the performance of a given task). The observation is thus made of this task rather than of the auditory behavior per se (Kamil & Rudegeair, 1972).

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Currently, one of the major problems involved in the evaluation of children's auditory discrimination abilities is that little normative data is available (particularly for children younger than age five). Thus, even if discrimination information is obtained, it is difficult to compare and interpret the findings meaningfully. Shepherd (1971) stated, "A review of the literature suggests that speech discrimination testing with the young child is not currently practiced to any large degree in audiology clinics."

In performing audiological testing on children, time is usually a major consideration--it is important to accomplish whatever testing is needed before the interest and attention of the child is lost. One way of manipulating the variable of time in an auditory discrimination task is to manipulate the context in which the stimulus items are presented. In a study of four, five and six year olds, Schwartz and Goldman (1974) found a differential effect between stimulus items presented as word pairs and the same words presented in either a carrier phrase or a "contextual sentence"--performance on the latter tasks was essentially equal, and significantly better than performance on the word-pairs. The authors attributed their findings to the children's utilization of the effects of coarticulation, as well as to usage of grammatical and semantic cues.

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Statement of Purpose

The primary purpose of this study was to compare the effects of three different stimulus contexts on the discrimination performance of four and nine-year-old children. Performance of the two groups on each task might answer the question: Is there a difference in the need for, and utilization of, certain kinds of cues in the discrimination performance of children in a developmental stage of discrimination, versus children at a relatively "mature" stage of discrimination ability? If the inclusion of additional cues serves to allow better discrimination performance, such cues should remain part of the testing procedure, or at least, recognition of their contribution to discrimination performance should be noted.

For the purpose of this study, an auditory discrimination test was constructed such that each stimulus item was presented: (1) in isolation; (2) preceded by a tone; (3) in the context of a carrier phrase. Each of these tasks was hypothesized to contain progressively more cues: the word-in-isolation contained only the semantic and acoustic cues of the word itself; the word preceded by the tone also contained the cue of an acoustic warning device; the word in the carrier phrase contained the additional cue of an acoustic and linguistic warning device.

Review of the Literature

In order to study the effects of stimulus context on

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discrimination performance in children, a discussion of some of the other variables known to be related to auditory discrimination ability and performance in both children and adults seems warranted. The following factors have been discussed by researchers in relation to speech sound discrimination: age, sex, articulation ability, language ability, socio-economic status, meaningfulness of stimuli, phonetic content of items, number of choices available for the response, type of response required, and the effects of noise. Some of the major research conclusions concerning each of these variables are presented below.

Wepman (1960) stated that auditory discrimination skills mature by the end of the eighth year. Templin (1957), whose study included children ages three through eight, found a consistent growth in discrimination ability with age, which slowed between the ages of four and one-half and five years, and apparently ceilinged at about the age of eight. Aten's (1970) findings were also in agreement with this. However, Goldman et al. (1970) stated that the development of discrimination follows a pattern more similar to that of other abilities such as intelligence, finally maturing in the late teens. They suggested that most measuring devices are not sensitive enough to point out the subtle improvement in discrimination ability in the pre-teen and teen years.

Templin (1957) found no significant difference in dis-

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crimination ability between sex at any age level, although girls at older ages consistently scored higher. Goldman et al. (1970), who studied a population ranging from age three to age eighty-four years, also found sex to be insignificant.

Winitz (1969) summarized eleven studies involving the relationship of discrimination ability and articulation skills, and reported that nine of the studies compared a control group (normal articulation skills) with an experimental group (defective articulation skills), and found a significant difference in discrimination abilities in favor of the control group. More recently obtained data (Monnin & Huntington, 1974) has suggested this relationship to be more specific. That is, children with articulation difficulties do not appear to have a generalized discrimination problem, but only a deficiency at discriminating their misarticulated sounds. Wepman (1960) stated that no consistent relationship between articulation and discrimination ability is found after the age of nine years. Stitt and Huntington (1969), however, found such a relationship in adults, and attributed the lack of significance obtained in past studies to be due to inadequacies of the measuring devices used.

Some studies have attempted to correlate language ability with discrimination performance. Templin (1957) found very low correlations between discrimination and vocabulary skills. Perozzi and Kunze (1971) obtained significant

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correlations between high discrimination scores and high performance on the subtests of verbal expression, manual expression, visual association and grammatical closure on the Illinois Test of Psycholinguistic Abilities (ITPA). The authors, however, did not speculate why these particular subtests appeared to be correlated with discrimination. Rechner and Wilson (1967) found that children with poor discrimination received significantly poorer scores on the ITPA subtests of grammatical closure and auditory memory than did the controls.

Some data indicate that socio-economic status (SES) is related to discrimination ability. Elenbogen and Thompson (1972) reported that children of higher SES consistently performed better on discrimination tasks than did lower SES children. An additional finding was that the lower SES children performed equally well on the nonsense syllable task as they did on the word task, while the high SES children performed better on the word task. However, problems with the study such as no control for normal hearing acuity or order effect, and different forms of the test used for each group, may have confounded the data. Templin (1957) found that although children of lower SES always received lower discrimination scores, no consistent significant differences at each age level were found. Templin suggested that her findings concerning SES may have reflected vocabulary and abstract abilities rather than discrimination abilities as such. Elenbogen

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and Thompson also suggested that their subject's language background may have been the determining factor.

It has been fairly well established that the meaningfulness of the auditory stimuli is related to discrimination performance. Prins (1963) stated that normal-speaking subjects can best discriminate minimal sound differences that are phonemic, that is, those sounds that signify a change in linguistic meaning. Adults have more difficulty discriminating nonsense syllables than they do meaningful monosyllables (Hirsh, 1952; Hirsh et al., 1954). The findings of LaForest (1973) would appear to support this--five year olds performed significantly better on meaningful material than on non-meaningful material. Fry (1964) stated that when the listener is asked to discriminate unfamiliar items, his unconscious knowledge of the "statistics of the language" is of no use--the probabilities of occurrence are not called upon. Tests of auditory discrimination that utilize nonsense syllables have been criticized because they are asking the listener to perform a task that he is never called upon to do (Berger, 1971). Others have claimed it to be desirable as a more "pure" test of auditory discrimination, uncomplicated by linguistic cues, word familiarity, etc. (Nagafuchi, 1974).

Related to the discussion concerning meaningfulness of stimuli is the factor of word familiarity. Owens, who studied the relative familiarity of words in standard adult discrimination lists, found that performance was better on lists that

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contained more familiar words (Owens, 1961). Brooks and Goetzinger (1966), however, found no significant effect of word familiarity on the discrimination scores of grade school children when "familiarity" was categorized according to multiordinality, abstractness and frequency of usage.

Campbell (1965) cited Egan's (1948) criteria for word selection for constructing a test of discrimination, including the criterion of equal phonetic composition among the words. Much controversy has existed concerning the phonetic balance of word lists, although some clinical and experimental findings have supported the non-essentiality of its contribution (Campbell, 1965; Davis & Silverman, 1970). Berger (1971) pointed out that the phonetic balance of many lists currently in use has been based on out-dated printed language, which is not representative of conversational speech. Phonetic content is, however, a prime consideration in discrimination, because certain phonemes are more difficult than others to discriminate. It has been found that the more nearly alike two phonemes are in phonetic structure, the more likely they are to be misinterpreted (Liberman et al., 1967). Miller and Nicely (1955) found that in a background of noise, of five articulation features studied, that of place of articulation was severely affected, while discrimination of other phonetic features, particularly voicing and nasality, was little affected. The findings of Binnie et al. (1974) supported these results.

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Closely related to the variable of phonetic content of stimulus items is that of range of alternative choices made available to the listener. Miller et al. (1951) stated that "discriminability is a function of the number of alternatives and the similarities among them." They concluded that the ease with which a given speech sound can be discriminated is partially dependent on the number of different sounds from which it must be differentiated, and that this number of alternatives available can be a gauge of task difficulty. Jerger et al. (1968) criticized the use of an "open set" in which no limits are placed on the range of possible responses, because it leaves the listener's previous linguistic history uncontrolled. Smith and Hodgson (1970), however, suggested that increasing the total set and requiring reliance solely on auditory cues may be a more valid measure of discrimination. They cautioned that closed-set measures can become complicated by a task of associational learning. Miller et al. found increasingly higher discrimination scores as the set of defined possibilities became more limited.

The response required of the listener is also a variable involved in speech discrimination performance, and becomes a crucial factor in testing children (Kamil & Rudegeair, 1972). For instance, there is evidence to suggest that the same/different judgment required by many discrimination tests may be too difficult for some children, particularly those under the age of five (Beving & Eblen, 1973). In addition, it is

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possible that a psychophysical bias exists on tests of this nature, such that the listener tends to employ both categories with equal frequency (Vellutino et al., 1972). Tests which require a pointing response to pictures limit the alternatives and add receptive vocabulary as a complicating factor. For very young children, though, there may be difficulty in getting a verbal response, so that a picture-pointing response may be most suitable (Northern & Downs, 1974). A disadvantage in requiring a verbal response is that the examiner may misinterpret the response due to the articulation of the listener or the hearing of the examiner (Jerger et al., 1968).

The effects of noise on auditory discrimination performance have been studied rather extensively (Miller, 1947; Pollack, 1948; Miller & Nicely, 1955; Kruel et al., 1968; Rupp & Phillips, 1969; Keith & Talis, 1970; Young & Harbert, 1970), both experimentally and clinically. Most available tests of auditory discrimination, though, are based on a measure obtained in quiet. A few studies have been involved with children's discrimination performance in noise (Goldman et al., 1970; Anderson, 1972; Schwartz and Goldman, 1974; Ehrlich & Tartaglia, 1973). The major finding was that noise results in reduced discrimination performance, which decreases as the signal-to-noise ratio decreases. However, Ehrlich & Tartaglia found that 38 percent of the children in their study performed better at a signal-to-noise ratio of

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+9 dB than they did in quiet. They suggest that the noise may have increased some of the children's attention set to the task.

Kruel et al. (1968) stated that measurements of discrimination performance in the presence of noise are probably more valid than in quiet, because verbal communication rarely takes place in quiet. Smith and Hodgson (1970) stated that there is currently a trend toward testing discrimination abilities under more difficult listening conditions. Two recently developed tests of discrimination, the Modified Rhyme Test (Kruel et al., 1968) and the Goldman-Fristoe Woodcock Test of Auditory Discrimination (Goldman et al., 1970), both employ controlled noise.

A review of existing tests of discrimination for both adults and children indicates that the majority of them utilize single monosyllabic words presented either in the context of a carrier phrase or as a word-pair. Although the limited applicability of assessing discrimination by response to single words has been pointed out (Jerger et al., 1968), there are many problems concerning the construction of test items for a discrimination test involving sentences or continuous discourse, including the variable of word predictability (Duffy & Giolas, 1974). Sentence work does not appear to be a profitable direction for discrimination testing with young children because the response either requires

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that the child can read, or if repetition of the sentence is required, it may introduce problems of auditory memory and linguistic factors (the utterances may not be within the range of the child's grammatical capacity).

Some studies concerning the effects of context of stimulus items on discrimination performance have been carried out. For instance, Hirsh et al. (1954) found that a contextual sentence containing a particular word resulted in greater intelligibility and greater resistance to noise interruption than if that word were presented in a carrier phrase. Martin et al. (1962) found that normal hearing subjects significantly preferred no carrier phrase, and their discrimination scores were not affected by the inclusion or exclusion of the phrase. Kruel et al. (1969) found a significant difference in the discrimination performance of adults using two different carrier phrases, although they noted that an "easily identified" word remained easily identifiable for each phrase. No explanation was offered for the differences. In a study of children's discrimination abilities in various contexts, Schwartz and Goldman (1974) found that although children performed most poorly on a task requiring a response to a stimulus word pair, there was no difference in their performance when the same words were used in either a carrier phrase or a meaningful sentence. However, it appears as though there was little difference

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between the last two conditions--the meaningful sentences were actually four sentences presented alternately. The authors suggested that in either of these contexts (sentence and carrier phrase), grammatical, semantic and phonological cues are available which make discrimination easier. Liberman et al. (1967) found that phonological redundancy is available such that several adjacent sounds carry information about a given specific sound, and this factor can be of major importance in speech perception. Those effects of coarticulation may make subtle additional cues available such that the information is more easily processed.

In conclusion, the above review of the literature basically reveals several variables to be related to speech sound discrimination, such that any study of one factor's relation to discrimination must take into account the effects of the other factors. The major conclusions discussed above can be summarized as follows:

Speech sound discrimination ability is known to mature at least through the eighth year, with no significant sex differences. Poor articulation skill appears to be positively related to poor discrimination skill at least through age eight as well. In addition to articulation skill, general language ability and linguistic experience are apparently positively related to discrimination performance. It has been suggested that since meaningful stimuli are more

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easily discriminated, language ability correlates positively with discrimination of meaningful words, but not with discrimination of non-meaningful stimuli.

Other variables are considered more intrinsic to the nature of the discrimination task than to the listener. These include the phonetic content of the test items and the range of alternatives available for the response. As discussed above, some phonetic features are easier to discriminate, and fewer response alternatives make the discrimination task less difficult. The effect of noise on the discrimination task is to make the task more difficult as the signal-to-noise ratio decreases. Lastly, the context in which the stimulus items are presented affects the difficulty of the discrimination task, and it is this variable that is of concern in the present study.

Statement of the Problem

It could be asked whether a carrier phrase in a discrimination task serves merely as a warning device (and could therefore be equated with a non-linguistic warning device such as a tone), or whether the linguistic features of that context provide additional useful cues to the listener. Another question is whether children with less-developed discrimination skills need and utilize cues to a greater extent than do children with more mature discrimination abilities.

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The primary hypothesis tested was that there would be a significant difference in the discrimination performance of four-year-old subjects for each of three stimulus contexts (isolated word; word preceded by a tone; word preceded by a carrier phrase), whereas performance by nine-year-old subjects would not vary according to stimulus context. Specifically, it was hypothesized that four year olds would perform progressively better as progressively more cues were added to the stimulus item (word alone; warning device plus word; linguistic warning device plus word), while the nine year olds would not need to depend on the additional stimulus-context cues, and would therefore perform equally well on each discrimination task.

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CHAPTER II

PROCEDURE

Materials

Three lists, each containing the same twenty-four monosyllabic stimulus items were constructed (see Appendix A). The items were equated for length and syllable structure by using the format of consonant-vowel-consonant (CVC). The consonant sounds used in the words were all within the articulatory repertoire of 75 percent of the four-year-old children tested by Templin (1957). This was done to avoid having many of the four-year-old subjects unable to correctly articulate the sounds to be discriminated, which could confound the results. Words meeting this criteria were then chosen from Haskins's (1949) four lists of phonetically balanced words for children (PBK's), whose two hundred words had originally been obtained from the International Kindergarten Union List--words found in the speaking vocabulary of young children. Each of the tested consonant sounds was represented at least once in both the initial and final position where applicable (e.g. /h/ occurs only initially in English). No attempt was made to obtain a phonetically balanced list.

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Instrumentation

All recording and testing was conducted in an Industrial Acoustics Company (IAC) testing suite, model number 1204 A-CTR. A Sony TC 366 three-head stereophonic tape recorder was used to record the stimulus items on a Realistic 1.5 mil x 600 tape at a recording speed of 7½ inches per second (ips). Each of the stimulus items was recorded following a one-second pause which was preceded by the carrier phrase, "You will say _____." The pause was inserted to avoid confounding the stimulus items with the effects of coarticulation of the carrier phrase. A five-second silent interval was allowed between each item and the beginning of the next carrier phrase. The speaker was an adult female who spoke General American English. The recorder was connected to channel one of a Grason Stadler 1701 audiometer, and the intensity of the carrier phrase was controlled by monitoring the VU meter on the audiometer and the tape recorder such that the carrier phrase peaked at 0 dB (±1 dB) on the meter. The hearing level (HL) dial was set at 55 dB. Prior to recording the list of stimulus items, a 1000 Hz calibration tone (monitored on the VU meter at 0 dB) had been recorded at 55 dB HL.

In order to assure that a given stimulus item was presented in an equal manner under each stimulus context, three copies of this master tape were made using two Uher 4000 Report-L tape recorders. The recording intensity was adjusted

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such that the carrier phrase peaked at -3 dB (±1 dB). One copy was left as originally recorded. The carrier phrases were spliced out of the other two tapes, which were treated as follows. One tape was reassembled to contain only the stimulus items, five seconds apart, in a random order determined by assigning each word from the original taping with a number from a random number table. The items from the other tape were reassembled in random order also, and a 1000 Hz tone (which had been recorded in the same manner and at the same intensity as the calibration tone) one second in duration, was inserted one second before each stimulus item. Stimulus items were five seconds apart.

This resulted in three tapes, consisting of the same twenty-four monosyllabic words in different order--one tape containing the words in isolation (1); one containing each stimulus preceded by a tone (2); and the third tape containing the words in the context of a carrier phrase (3). The 1000 Hz calibration tone preceded each tape. The lists were then taped into the following three orders, using the Uher recorders at the same recording intensity as had been used for making the copies described above: (1)(2)(3); (2)(3)(1); and (3)(1)(2). The three orders were designated by the terms Condition A, B and C, respectively.

All recorded lists were subsequently judged to be free of articulation and distortion abnormalities by a panel of

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six graduate students in Communication Science and Disorders. The lists were presented through both speakers in the IAC booth. Each student wrote his response to each stimulus item, and was also instructed to mark items which were distorted in any way. Agreement by five of the six (at least five of them recorded the correct stimulus item and did not mark it to be distorted) was required for the item to be acceptable. None of the twenty-four words on any of the tapes were judged to be abnormal by any of the judges.

In order to prevent subjects from obtaining perfect scores, and to make the listening situation somewhat more comparable to a "usual" listening task, the lists were all presented in a background of white noise at a signal-to-noise ratio of +10 dB. This level was found by Anderson (1972) to be sufficiently difficult for four, five and six year olds without creating a complete breakdown in discrimination performance.

The noise was generated through channel two of the audiometer at a hearing level of 45 dB, and recorded by the Sony tape recorder on the lower track of the speech stimuli tapes at a speed of 7½ ips. For the recording of the noise, the VU meter of the audiometer and of the recorder were set to 0 dB. The noise was preceded by a 1000 Hz calibration tone with the HL dial and VU meters adjusted as for the recording of the noise.

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Table 1 presents the hearing and sound pressure levels for the various output sources of the completed tapes as measured by a Bruel and Kjaer (B & K) sound level meter, type 2203. The tapes were played through the audiometer into a TD H49 10Z earphone mounted on an MX 41/AR cushion. The VU meter of the audiometer was adjusted to -6 dB to the calibration tones for both speech and noise tracks prior to obtaining any measurements. The hearing levels for speech (channel one) and for noise (channel two) were set at 55 and 45 dB HL, respectively.

TABLE I

Hearing Level and Sound Pressure Level Measurements for Various Output Sources of the Completed Tapes as Measured at the Earphone

Output	HL (dB)	SPL (dB)
Speech Track:		
1000 Hz Calibration Tone	55	62-63
Stimulus Items	55	56-62
Peak of Carrier Phrase (3)	55	61-64
1000 Hz Warning Tone (2)	55	62-64
Noise Track:		
1000 Hz Calibration Tone	45	52-53
White Noise	45	51-53

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Subjects

Thirty four-year olds (range: 4:0 to 4:9, mean age 4:5) and thirty nine-year olds (range: 9:0 to 9:9, mean age 9:3), all obtained from private nursery or from elementary schools in the Missoula, Montana area, participated in the study. The following additional criteria were established: 1) normal hearing according to an audiometric screening at 15 dB (ANSI) of each ear under earphones, for the octave frequencies from 500-4000 Hz; 2) ability to correctly articulate each of the sounds tested in the discrimination tasks, demonstrated by correctly articulating the names of pictures containing those sounds (using words other than those on the discrimination lists); 3) normal language ability, as assessed informally by the experimenter.

Experimental Procedure

Sound pressure levels of the calibration tones for both speech and noise for each tape were obtained separately with the B & K sound level meter at the earphone, prior to, and following, each day's testing session. The hearing level dial for the channel containing the speech was set at 55 dB and for the channel containing the noise at 45 dB, with the VU meter adjusted to -6 dB for each channel.

The child was first taken into the experimenter's side of the testing booth and was told that this was where the experimenter would be. The room where the child would be

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was pointed out through the one-way mirror. The child was told that he would not be able to see the experimenter, but the experimenter would be able to see him. This aspect of the procedure was judged by the experimenter to be important in reducing possible anxiety concerning the testing environment, therefore increasing the probability that the child would successfully complete the task. At this time, the experimenter prepared each four-year-old child for the audiometric screening by conditioning a hand-raising response to presentation of pure tone signals.

The child was then brought into the patient side of the suite. Following administration of the articulation and language screening, he was shown a large sack of wrapped prizes, and he was told he could choose any prize when he was finished. Instructions for the hearing screening were given, and the earphones were placed on the child, who was seated in clear view of the one-way mirror. The experimenter went into the other room to begin the screening.

As stated previously, the three stimulus contexts had been taped to create three different orders of presentation, designated by the terms Condition A, B and C. Each child was randomly assigned to one of these conditions so that ten children from each age group received each of the three possible presentation orders. Before beginning the test, the tape was calibrated to the 1000 Hz reference tones for both speech and noise by adjusting the VU meter to -6 dB for each

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channel. The speech and noise were then fed through the audiometer simultaneously into the right and left earphones (type TD H49 10Z on MX 41/AR cushions) at 55 and 45 dB HL, respectively.

Instructions for each task were administered verbally (see Appendix B). It was decided by the experimenter that the lack of flexibility afforded by using taped instructions, and the likelihood that many of the four year olds might not fully understand the task with taped instructions, outweighed the variability that might be introduced by this procedure. The experimenter attempted to give the instructions in an equal manner across tasks and across subjects. Following the instructions, practice items (using words from the articulation screening), presented at a signal-to-noise ratio of +20 dB (55 db HL for speech, 35 dB HL for white noise) and within the appropriate context, were administered. The child was trained to perform the task correctly on three out of four items before the taped word list of that task was begun.

A thirty-second break was given between tasks, during which time the experimenter told the child that he was doing a good job, and that he could rest while she was preparing the next task. The experimenter did not intend to interact with the child during the actual presentation of the word lists. However, many of the four year olds interrupted the

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task to ask questions or make comments, and the experimenter found that the child often became frightened and/or inattentive to the next item if no response was made. However, information concerning how well the child was performing or how many items were left, etc., was not given, and the child was encouraged not to interrupt.

Scoring

A data sheet (see Appendix A for a sample) was kept for each child. Responses were scored (+) if the entire word was repeated correctly; a phonetic transcription was made of the response if any part of the word was incorrect, and this was counted as one error, regardless of the number of phonemes that had been misinterpreted. The total number of correct words for each stimulus context was not tallied on the data sheets until the data on all sixty children had been collected. During the testing session, a Uher 4000 Report-L tape recorder on the child's side of the testing suite served to record the experimenter's administration of the instructions as well as the child's responses to the stimulus items. This information was then used if the experimenter wished to recheck any of the child's responses.

Experimental Design

A complex Latin square design was used, whereby each age level (four and nine year olds) received three treatments

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(word in isolation, word preceded by a tone, and word in a carrier phrase), so that an equal number of subjects in each group received the tasks in a systematically counter-balanced order. Scheffé contrasts were used to assess significant main effects. In all cases, the .05 confidence level for statistical significance was chosen.

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CHAPTER III

RESULTS

The data analyzed in this study consisted of a score (number correct) for every subject for each of three contextually different monosyllabic word lists. The results were evaluated by a three-way analysis of variance for repeated measures technique. The factors under consideration included (1) age (four and nine year olds); (2) context (word in isolation, word preceded by a tone, and word preceded by a carrier phrase); and (3) order of presentation. The primary hypothesis tested was that four year olds would perform progressively better as more contextual cues were introduced into the discrimination task, whereas nine year olds would perform equally well across all three contexts.

The values for all of the statistical analyses presented here were obtained from the raw data presented in Appendix C. All results were tested at the .05 level of confidence. Table 2 presents the mean raw score and standard deviation for each of the groups with age, context and order of presentation considered. The summary of the analysis of variance of the data is presented in Table 3.

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TABLE 2

Mean And Standard Deviations for Raw Scores
by Age, Order of Presentation and Context

ORDER OF PRESENTATION	STIMULUS CONTEXT: Word Alone $\bar{X}$	Word Alone s	Tone and Word $\bar{X}$	Tone and Word s	Carrier Phrase and Word $\bar{X}$	Carrier Phrase and Word s
			Four Year Olds			
First	17.8	1.1	16.5	2.5	15.4	1.5
Second	16.7	1.7	16.2	2.1	16.8	2.3
Third	18.0	2.1	16.4	2.9	17.4	1.7
			Nine Year Olds			
First	20.4	2.6	20.0	2.2	19.7	2.2
Second	20.7	2.8	19.6	2.2	19.0	1.3
Third	20.5	1.7	21.4	2.2	20.9	2.2

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TABLE 3

Summary of the Analysis of Variance of Scores on Three Contextually Different Measures of Discrimination

Source	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
BETWEEN GROUPS	1096.911	59		
Age	533.889	1	533.889	53.787+
Context x Order	3.612	2	1.806	.182
Context x Order x Age	23.409	2	11.704	1.179
Error	536.001	54	9.926	
WITHIN GROUPS	356.000	120		
Context	22.678	2	11.339	4.292*
Order	30.578	2	15.289	5.787*
Context x Order	7.643	2	3.822	1.447
Context x Age	6.810	2	3.405	1.289
Order x Age	1.642	2	.821	.311
Context x Order x Age	1.250	2	.625	.236
Error	285.399	108	2.642	
TOTAL	1452.911	179		

+F.05, df 1 and 54 = 4.03

*F.05, df 2 and 108 = 3.09

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The findings of the analysis of variance indicate that nine year olds scored significantly higher ($\bar{X}$ = 20.5) than four year olds ($\bar{X}$ = 16.8). In addition, scores differed significantly according to the order of presentation and according to stimulus context. No interactions, including the interaction of major interest to this study (age by context), were statistically significant.

Scheffé contrasts were performed on mean scores for the main effects of context (without considering age and order of presentation), and of order (without regard for age and context). The F ratios for these analyses are reported in Tables 4 and 5, respectively.

TABLE 4

Comparison of Mean Values for Context with Scheffé Contrasts

Comparison	Means	F Value
Word Alone vs. Word Preceded by Tone	19.0 - 18.4	5.057
Word Alone vs. Preceded by Carrier Phrase	19.0 - 18.2	7.580*
Word Preceded by Tone vs. Word in Carrier Phrase	18.4 - 18.2	.250

TABLE 5

Comparison of Mean Values for Order with Scheffé Contrasts

Comparison	Means	F Value
First vs. Second	18.3 - 18.2	.204
First vs. Third	18.3 - 19.1	7.272*
Second vs. Third	18.2 - 19.1	9.886*

*$F'.05$, df 2 and 108 = 6.18

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The results for context indicate that discrimination performance on the word-in-isolation context was significantly better than performance on the word in a carrier phrase. Although it was not significant, there was a trend toward better performance on word-in-isolation compared with performance on the word preceded by a tone. There was no significant difference between performance on the contexts of warning tone and carrier phrase.

Scheffé contrasts for order of presentation revealed that performance was significantly better on the third presentation than on both the first and second presentation orders. There was no significant difference in performance between the first and the second presentations.

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CHAPTER IV

DISCUSSION

The central question in this study was whether normal children's auditory discrimination performance would differ as a function of the context in which the stimulus items were presented. The same stimulus items (monosyllabic CVC words) were presented in three different contexts (in isolation; preceded by a tone; preceded by a carrier phrase) to thirty four-year olds and thirty nine-year olds. It was expected that the four year olds would perform better as the context included more cues, while the nine year olds' performance would not be affected by stimulus context. In order to avoid the possibility of confounding the effects of stimulus context with a practice effect (i.e., having every child receive each list in the same order), three different orders of presentation were included in the study.

Performance by Age

The finding that the discrimination performance of the nine year olds was significantly better than that of the four year olds was not unexpected, since auditory discrimination is a skill that develops at least through the eighth year

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(Templin, 1957; Wepman, 1960; Aten, 1972). Because little normative data is available concerning expected auditory discrimination performance for children, it is difficult to compare the findings obtained in this study with those of other studies. This is particularly so since the discrimination scores obtained here were obtained in a background of noise (S/N = +10 dB). The Goldman-Fristoe-Woodcock (G-F-W) Test of Auditory Discrimination (Goldman et al., 1970) includes normative data for both of the age groups tested in this study under a similar noise condition (S/N = +9 dB). However, the extent to which these findings can be compared is questionable, since the G-F-W is a closed-set test (responses are limited to four choices), and employs only one of the contexts (a carrier phrase) used in the present study. The Denver Auditory Sequencing Test (Aten, 1972) also uses a closed set, and measures discrimination in quiet. Haskins's (1949) Phonetically Balanced Kindergarten lists (PBK's) use an open-set format, but provides no norms for either quiet or noise.

Order of Presentation

It was expected that performance would improve progressively from the first through the third presentation of the stimulus items, regardless of age and context. However, it was found that there was essentially no difference in performance from the first to the second presentation. Difference in perfor-

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mance between the third presentation and both first and second presentations was statistically significant in favor of the third-presented list.

The experimenter was initially concerned that a fatigue effect might create poorer discrimination scores on the last presentation, particularly for the four year olds. Its effects, if any were operative, were offset by the apparent practice effect that took place from the second to the third presentation.

This information concerning an order effect is in contrast to the findings of Schwartz and Goldman (1974), who found order not to be significant in children's performance on three contextually-different discrimination tasks. However, Goldman and Schwartz were using a response set limited to three choices. One of the three stimulus contexts required a response to a pair of stimulus items, whereas the other two tasks demanded responses to a singly-presented item. Perhaps both the limits set on response alternatives as well as the difference in tasks rendered any practice effects insignificant in their study.

The improved performance on the third-presented task may be related in a sense to increased word familiarity. Although all stimulus items were chosen from a set of words taken from the vocabulary of pre-school children (and therefore assumed to be familiar), all of the words may not have been equally

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familiar to all of the children. However, hearing the same word three times within a relatively short (approximately ten minutes) time period may have served to increase familiarity of the items and increase the chance of correct discrimination on the third presentation. The children were not informed that they would receive the same words more than once, but many of them apparently came to that conclusion on their own. Remarks during the third-presented list such as "I know - these are just mixed up this time" and "I already said that once" were fairly common among the children of both groups.

An additional explanation for the better performance on the third task is that evidence suggests that the same auditory information becomes more easily discriminated by the fact of repetition alone (Pollack, 1959). Possibly this effect was operating even though a given item was not presented three times in succession. Since the interaction between order and context was not significant, it would appear that the repetition of the stimulus regardless of the context was sufficient to contribute to significantly better discrimination performance.

It should be noted that in the present study, the effects of sequence were not controlled, in that presentation of each context did not follow presentation of every other context an equal number of times. However, it was decided that in order to increase the chance for showing an order effect if it existed, it was more important to protect the cell size by

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maximizing the number of children receiving each condition. Although no evidence could be found in the literature to suggest that sequence does affect children's discrimination performance, it should be recognized as a potential variable that was not controlled in this study. The effects of sequence, if any were present, were therefore not analyzed by the design employed, but remain as unexplained variance between the three contexts.

Stimulus Context

The effects of stimulus context revealed unexpected findings. The experimenter had hypothesized that there would be an interaction between age and context such that the four year olds would perform differently as a function of the context of the stimulus items. No such interaction was found. In addition, it had been predicted that the nine year olds would perform equally well regardless of context.

Analysis of the data, however, revealed that for both age groups, performance on the word-in-isolation was significantly better than for performance on the word in the carrier phrase. Although the difference was not significant between the word preceded by the tone and the word-in-isolation, the trend was in favor of better performance on the isolated word context. There was no significant difference between the contexts of tone and carrier phrase.

It could be concluded from these results that the tone

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and carrier phrase did not appear to function as useful additional cues in aiding the discrimination performance of the four year olds, nor did they function as superfluous cues for the nine year olds. Rather, they appeared to actively distract both groups of children such that their performance when given only the stimulus items alone was better, and significantly so when compared with the carrier phrase context.

The experimenter noted that many of the four year olds laughed at the tone or tried to imitate it, although no such reactions were noted from the nine year olds. The carrier phrase appeared to confuse both groups. Prior to administering the items in this context, the experimenter trained the child to respond only with the stimulus item on the practice trials. It was typical, however, for many of the children to repeat the carrier phrase sporadically during the test itself, and to try to correct themselves, apologize, etc., often while the stimulus item was being presented. It is possible that this behavior interfered with their discrimination performance.

At least for children in the two age groups tested, then, it appears that a warning device (whether it is linguistic or non-linguistic), does not increase the child's attention to the task. Rather, a set merely to attend and respond to the stimulus item alone appears to allow for optimal discrimination in this type of discrimination test (i.e., a test that uses singly-presented monosyllabic words with an open-set response format). The "cues" provided by the tone and carrier phrase

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distracted the children from the discrimination task--both a group of children considered to be at a rapidly developing stage of discrimination (Templin, 1957), and a group of children considered to have relatively mature discrimination abilities (Templin, 1957; Wepman, 1960).

This information concerning carrier phrase effects may be of particular importance in a clinical setting when an assessment is being made of a child's discrimination performance. Martin et al. (1962) found that while adults significantly preferred to have discrimination items presented in isolation to presentation in a carrier phrase, their performance did not differ significantly in either context. The data obtained in the present study indicate that the carrier phrase had a detrimental effect on discrimination performance of the two groups of children studied.

A major implication is that the inclusion of the carrier phrase in auditory discrimination testing of children should be further examined. It is apparently widely used in testing both adults and children in a variety of test formats (e.g., Kruel et al., 1968; Goldman et al., 1970; Aten, 1972). Particularly in testing young children, when time is an important factor, the inclusion of the carrier phrase can increase total testing time considerably, which may result in limiting both the quantity and quality of the information obtained. If this procedure results in poorer discrimination scores as well as

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additional testing time, its usefulness ought to be reassessed.

It is realized that in the present study, a pause of one second was deliberately inserted between the carrier phrase and the stimulus item, thus destroying coarticulatory effects. It is feasible that these effects are normally present in clinical administration of discrimination tests when a carrier phrase is used, and they may enhance discrimination to some extent. However, it seems doubtful to the author as a result of this study that the confusion or distraction that the carrier phrase appears to create would not be effective, even in the presence of coarticulation.

Another use of the carrier phrase in discrimination testing (in addition to providing an alerting signal and coarticulatory cues) is to ensure presentation of the stimulus items at a relatively consistent intensity. Due to the acoustic characteristics of the monosyllabic words that are used in many discrimination lists, it is unrealistic to attempt to present each word at the same intensity level. Instead, the carrier phrase is used to monitor intensity, with the stimulus items spoken with "equal effort rather than with equal intensity" (Newby, 1972). The necessity and effectiveness of the carrier phrase with regard to this function was not a consideration in this study, although this purpose should be evaluated as a factor in determining the advisability of including or excluding the carrier phrase in tests of discrimination.

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Stimulus Items

Since the study was concerned with the children's response to three discrimination tasks which varied only by context and order of presentation (with the same stimulus items, though differently ordered across contexts), the performance on individual stimulus items was not submitted for analysis. However, the raw error scores for each item as a function of age, context and presentation order are included in Appendix D.

It can be observed that some words had a relatively high error rate for both groups (e.g., "bug"), while some had a relatively high error rate for one group only (e.g., "hook" for four year olds; "night" for nine year olds). Some words, such as "neck" and "good" had a very low error rate for both groups. It has been suggested that one criterion for constructing a test of discrimination is to exclude items which are either almost always, or almost never, missed (Campbell, 1965). Some of the very infrequently missed items on the list used in this study, therefore, could be considered to add to test length without contributing to discriminability.

The experimenter noted some interesting response patterns in both groups of children. One of the most prominent was that the children rarely responded with an item that was not an actual word. Although they made significantly fewer errors, the nine year olds as a group seemed to respond with a wider variety of error responses to a given item. For

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example, the four year olds' most frequent error response to "dime" was "time," while the nine year olds responded with "time," "stein," and "dine" almost equally. Perhaps this could be attributed to, in part, by the increased vocabulary size of the nine year olds which, in effect, increases the size of the open set (although the better-developed discrimination skills of the nine year olds results in better discrimination performance despite the wider range of alternatives that are theoretically available to them). A systematic study of the error patterns on discrimination items made by various age groups might provide some useful and interesting information, particularly if one were attempting to construct a standardized test of children's discrimination performance.

Recommendations

Based on the findings obtained by the present study, the following recommendations are made:

1. Further investigation of the effects of the carrier phrase on discrimination performance should be conducted on tests utilizing different types of response sets, and including a broader range of age groups, so that the information could be extended to include children of more ages than the present study allows.

2. Normative data, particularly for open-set discrimination tests demanding verbal responses is lacking for

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children, making it difficult to interpret obtained scores. It is therefore recommended that such data be gathered and made available, particularly on such frequently used tests as the Phonetically Balanced Kindergarten (PBK) lists. In addition, it is recommended that stimulus items on children's discrimination tests be examined for current familiarity and frequency of usage among the appropriate age groups to be tested.

3. Although many authors and audiologists claim that it is difficult for young children to perform open-set verbal response discrimination tasks, this was not the case with the four year olds tested in the present study. None of the children failed to comprehend the instructions or to perform the task appropriately. However, since these children were purposely chosen from a "normal" population, it would be expected that they could more easily adapt to such a task than would hearing- or language-impaired children. Nonetheless, it would seem advisable, in view of the quality of information obtainable on an open-set test, to attempt to administer such a test. A closed-set test could be used only as a second alternative, rather than making the presumption that the child cannot perform the open-set task.

4. It is suggested that the effect of stimulus context on children's discrimination be assessed as a function of various signal-to-noise ratios, particularly since this kind

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of information could potentially be useful in identifying children with normal peripheral hearing who have auditory perceptual problems (Katz & Illmer, 1972).

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CHAPTER V

SUMMARY AND CONCLUSIONS

An investigation was made to determine if stimulus context would affect discrimination performance of two age groups of normal hearing children.

Thirty four-year olds and thirty nine-year olds, who evidenced normal hearing and language skills, and the ability to correctly articulate the sounds used in the discrimination task, took part in this study. Each child was administered three discrimination lists containing the same twenty-four monosyllabic words within the context of: (1) word-in-isolation; (2) word preceded by a tone; (3) word preceded by a carrier phrase.

The results were evaluated by a three-way analysis of variance for repeated measures involving the factors of age, order of list presentation, and context of stimulus items. The results indicated the main effects of age, order and context all to be statistically significant. The .05 level of confidence was chosen.

The effect of major interest to the study, that of the interaction between age and context, was found not to be significant. Further analysis of the main effects of context and order revealed that performance on the word-in-

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isolation was significantly better than on the carrier phrase for both groups of children; performance on the third-presented list was significantly better than on either the first- or second-presented lists. It was therefore concluded that stimulus context and order each affected both groups of children in the same manner. The data failed to support the experimenter's primary hypothesis that the performance of the four year olds would improve progressively as a function of added contextual cues, while the performance of the nine year olds would be unaffected by context.

The major implications of the study were that: (1) the role of the carrier phrase in children's discrimination testing should be reassessed; (2) the use of an open-set discrimination task demanding a verbal response appears to be potentially valuable in assessing discrimination in children as young as age four.

Recommendations were made for further studies related to auditory discrimination abilities in children.

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SUBJECT DATA SHEET

Name_____ Age_____ Condition_____
Subject No._____ Sex_____ # correct (1)_____
Birthdate_____ Date_____ (2)_____
(3)_____

Isolated Word (1)	Word and Tone (2)	Word and Carrier Phrase (3)
mine_____	wake_____	bug_____
dish_____	bad_____	bush_____
gun_____	cat_____	wake_____
knife_____	put_____	fat_____
hook_____	dish_____	tongue_____
tongue_____	bush_____	take_____
wake_____	gun_____	night_____
got_____	hook_____	wide_____
bush_____	wait_____	knife_____
shop_____	wide_____	dish_____
pig_____	shop_____	pig_____
take_____	good_____	got_____
bad_____	mine_____	shop_____
good_____	knife_____	gun_____
bug_____	dime_____	put_____
cat_____	night_____	bad_____
fat_____	got_____	cat_____
neck_____	food_____	mine_____
wide_____	take_____	wait_____
food_____	neck_____	good_____
night_____	tongue_____	neck_____
put_____	fat_____	food_____
wait_____	bug_____	dime_____
dime_____	pig_____	hook_____

Key: A - (1)(2)(3)
B - (2)(3)(1)
C - (3)(1)(2)

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A P P E N D I X B

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INSTRUCTIONS FOR THE DISCRIMINATION LISTS

Word in Isolation (1)

Name, I have some words I want you to say. I'll say a word and you say it back to me just like I say it. Let's practice a few first. (Present items from practice list below until the child performs correctly on three out of four, at a signal-to-noise ratio of +20 dB).

Okay, listen hard and say each word just like you did on these.

Word Preceded by Tone (2)

Name, I have some words I want you to say. First you will hear a sound like this (present 1000 Hz tone for one second, then ask, "Did you hear that sound?"), and then you will hear me say a word. Say the word back just the way you hear it. Let's try a few just for practice. (Present items from practice list below, each preceded by the tone and at S/N = +20 dB, until the child performs correctly on three out of four items).

Are you ready? Listen hard and say the words back.

Word in the Carrier Phrase (3)

Name, I'm going to tell you to say some words and I want you just to say the word I tell you to say. Let's do a few for practice. (Present items from list below in the phrase, "you will say . . ." at S/N = +20 dB until child performs correctly on three out of four. If necessary to train child to perform appropriately, say, "No, don't say the whole thing, just the word I tell you to say.").

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That's fine. Let's start now. Remember, just say the word I tell you to say.

Practice items:

bed	gum	pan
cup	hat	shoe
dog	milk	tub
fish	nose	wing

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APPENDIX C

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SUMMARY OF RAW SCORES BY AGE, CONTEXT AND ORDER

FOUR YEAR OLDS				NINE YEAR OLDS			
S #	Word Alone	Tone & Word	Phrase & Word	S #	Word Alone	Tone & Word	Phrase & Word
	First	Second	Third		First	Second	Third
1.	17	17	15	31.	19	17	18
2.	19	17	16	32.	22	17	17
3.	18	18	17	33.	14	17	20
4.	18	15	20	34.	23	21	23
5.	19	15	18	35.	22	18	22
6.	19	12	19	36.	23	23	21
7.	16	16	16	37.	22	19	23
8.	18	19	16	38.	20	23	23
9.	16	14	17	39.	20	21	23
10.	18	19	20	40.	19	20	19
	Third	First	Second		Third	First	Second
11.	18	16	14	41.	21	21	18
12.	17	20	19	42.	17	16	18
13.	17	18	17	43.	19	18	18
14.	17	19	16	44.	19	19	20
15.	20	14	19	45.	22	21	22
16.	13	12	14	46.	23	23	18
17.	19	15	18	47.	21	20	18
18.	20	15	14	48.	20	19	18
19.	21	20	21	49.	22	24	20
20.	18	16	16	50.	21	19	20
	Second	Third	First		Second	Third	First
21.	19	19	15	51.	19	21	20
22.	17	18	17	52.	14	17	15
23.	19	21	17	53.	18	19	20
24.	16	14	17	54.	23	23	19
25.	16	17	16	55.	22	22	21
26.	14	11	13	56.	20	20	17
27.	17	18	16	57.	22	21	22
28.	14	13	14	58.	23	24	21
29.	17	18	13	59.	23	24	23
30.	18	16	16	60.	23	23	19

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A P P E N D I X D

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NUMBER OF ERRORS ON EACH STIMULUS ITEM BY AGE, CONTEXT AND ORDER

FOUR YEAR OLDS

Items	Isolated Word			Tone & Word			Phrase & Word			Total
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
bad	1	2	3	4	4	4	5	3	4	30
bug	9	6	3	1	9	8	7	5	7	55
bush	1	4	3	4	2	3	7	3	0	27
cat	0	0	1	1	5	3	0	3	5	18
dime	1	0	2	3	1	3	0	0	2	12
dish	4	5	0	3	2	5	4	3	1	27
fat	4	3	3	5	5	4	2	7	4	37
food	1	3	2	4	5	0	0	1	2	18
good	0	0	0	1	1	1	0	0	0	3
got	2	3	4	1	2	2	2	6	2	24
gun	1	0	1	3	2	0	1	0	1	9
hook	6	7	5	5	1	6	10	5	2	47
knife	2	3	6	6	2	3	6	6	7	41
mine	5	4	3	4	4	2	2	3	5	32
neck	0	0	0	0	0	0	0	0	0	0
night	1	0	0	0	3	0	1	0	0	5
pig	4	5	3	3	4	7	9	4	2	41
put	5	6	5	7	6	6	6	5	5	51
shop	7	6	5	5	7	3	4	4	5	46
take	4	6	5	6	7	3	8	8	5	52
tongue	2	5	3	4	3	4	6	5	3	35
wait	0	0	1	2	1	4	1	0	1	10
wake	2	1	2	2	1	2	1	1	1	13
wide	0	4	0	1	1	3	4	0	2	15

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NINE YEAR OLDS

Items	Isolated Word			Tone & Word			Phrase & Word			Total
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
bad	1	2	1	4	3	2	1	3	0	17
bug	4	5	2	4	5	5	7	4	3	39
bush	1	2	2	1	1	1	2	3	1	14
cat	0	3	0	1	4	3	0	0	3	14
dime	2	0	2	1	2	0	2	3	2	14
dish	1	2	0	0	1	2	2	1	3	12
fat	2	4	7	5	3	2	3	7	4	37
food	0	0	0	1	2	0	1	0	0	4
good	0	0	0	0	0	0	0	0	0	0
got	0	2	1	1	0	1	0	2	1	8
gun	4	0	0	0	0	0	0	0	1	5
hook	3	0	0	1	0	1	0	1	0	6
knife	2	3	3	5	4	3	7	6	4	37
mine	0	0	1	1	2	0	0	1	0	5
neck	1	0	2	0	0	0	0	1	0	4
night	3	1	0	1	0	0	2	3	0	10
pig	4	2	6	5	5	1	4	5	2	34
put	2	2	3	6	3	1	1	2	1	21
shop	2	3	2	2	5	1	3	2	5	25
take	2	0	2	0	2	1	4	3	0	14
tongue	1	0	0	1	1	0	1	0	1	5
wait	0	0	1	0	0	1	1	0	0	3
wake	0	1	0	0	0	1	0	3	0	5
wide	1	1	0	0	1	0	2	0	0	5

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