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I am submitting herewith a thesis written by Sara E. Jennings entitled "A Comparison Between Behavioral Observation Audiometry and Visual Reinforcement Audiometry Utilizing Six Different Auditory Stimuli." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Audiology.

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# A COMPARISON BETWEEN BEHAVIORAL OBSERVATION AUDIOMETRY AND VISUAL REINFORCEMENT AUDIOMETRY UTILIZING SIX DIFFERENT AUDITORY STIMULI

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Sara E. Jennings

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# DEDICATION

This thesis is dedicated to my parents, Charles and Audrey Jennings. It is because of their support and confidence that I was able to undertake and complete this thesis.

A special debt of gratitude is extended to my mother who spent countless hours in typing legible rough drafts from my oftentimes illegible handwriting.

S.E.J.

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ABSTRACT

The purpose of this study was to investigate the use of six complex stimuli (complex noise, filtered complex noise, white noise, filtered white noise, speech, filtered speech) in the following conditions: (1) to determine if one or more of the stimuli could reduce the reported normal range of responding in behavioral observation audiometry (BOA) and make it a valid test for improving the accuracy of early identification of hearing loss in infants; (2) to compare two methods (BOA and visual reinforcement audiometry: (VRA)) when using the same subjects; and (3) to determine how the six stimuli breakdown in terms of mean intensity levels when reinforcement was added to the assessment procedures.

Ten infants were divided into two groups: Group 1 (2 to 4 month olds) was tested in the BOA condition with the six stimuli; and Group 2 (6 to 8 month olds) was tested in the BOA condition and the VRA condition with the six stimuli.

Results indicated that the BOA ranges cannot be further reduced because infants below 5 months of age cannot be conditioned to respond systematically. Visual reinforcement reduced the response thresholds but was not appropriate for infants below 5 months of age. Therefore, it was concluded that the wide response ranges obtained in BOA were typical and it would remain a screening procedure.

Visual reinforcement reduced the response thresholds for infants 5 months and older. Comparison of the BOA and VRA mean thresholds supported the use of visual reinforcement with the appropriate age range.

Stimulus type was an important factor in BOA. The type of stimulus utilized effected the infant's response. Complex noise appeared to be the optimal stimulus to use in the BOA condition. However, a high frequency hearing loss may not be detected by complex noise alone. Therefore, high pass filtered white noise appeared to be an optimal stimulus to use in the high frequency assessment of an infant's hearing abilities based on the results of this study.

Visual reinforcement was the primary factor influencing results in VRA, followed by stimulus type which showed a minor effect. With all stimulus types the infant's hearing sensitivity was considered within normal limits.

It was concluded that early assessment of an infant should include BOA and VRA at the appropriate ages.

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## LIST OF ABBREVIATIONS

BOA: behavioral observation audiometry

VRA: visual reinforcement audiometry

Hz: Hertz

dB: decibel

SPL: sound pressure level

HTL: hearing threshold level

CN: complex noise

FCN: filtered complex noise

WN: white noise

FWN: filtered white noise

Sp.: speech

F. Sp.: filtered speech

# CHAPTER I

## INTRODUCTION

Early identification and assessment of hearing loss in infants leads to early intervention both medical and/or educational. The earlier the hearing loss is identified in a child, the earlier intervention can take place. It is important that an infant be stimulated auditorily for normal speech and language to develop, otherwise communication problems will develop such as delayed language, articulation problems and problems with auditory processing and auditory memory. These problems may lead to academic and social problems if the child's hearing loss is not identified and managed at a very early age.

There are several approaches taken in newborn screening. They include parental screening, High Risk Register (HRR), Auditory Brainstem Response Audiometry (ABR), Crib-o-gram, Middle Ear Reflexes, Sensitivity Prediction from the Acoustic Reflex (SPAR), and Behavioral Observation Audiometry (BOA). The parental screening approach consists of questions asked on a High Risk Register and was suggested by the Joint Committee for Infant Screening (1972). It was designed to ". . . identify neonates in whom the probability of hearing loss could be expected to be higher than normal." The high risk criteria include a history of childhood hearing loss in the family; maternal intrauterine infections; low birthweight; ear, nose, or throat defects; and high bilirubin levels. However, the problem to this approach is a high percentage of false-positives: infants considered by the high risk register to be at risk for a hearing loss but have normal hearing. Downs (1976) and Feinmesser and Tell (1976) reported a false-positive rate of 7.8% when the high risk register is used with stringency.

Electrophysiological measures deal with the monitoring of internal changes resulting from auditory stimulation. The Auditory Brainstem Response (ABR) reflects the activity of the cochlea at approximately 2000 Hz and above, and therefore it will not reveal a low frequency hearing loss. In order to electrophysiologically map out an audiogram on an infant, it must be combined with the Frequency Following Response (FFR). With these two electrophysiological measures combined, a clinician may be able to make a statement on the infant's hearing status across a wide frequency range. However, these measures are expensive and time consuming. Additionally, ABR Audiometry reveals a significant false-positive rate. Galambos, Hicks, and Wilson (1982) reported a false-positive rate of 26%: 42 adults out of 160 identified by ABR Audiometry as having a hearing loss, had normal hearing.

The Crib-o-gram is another measure, utilizing a motion sensitive transducer placed beneath the infant's crib. A graphic level recorder automatically records motor activity prior to, during, and immediately after the presentation of a stimulus. The transducer can pick up anything from an eye blink or oral movement to a total body response. If the baby's behavior changes during and after the presentation of an auditory stimulus, a correct response is recorded.

A major criticism of the Crib-o-gram is the intensity of the stimulus, 92 dB SPL. The Crib-o-gram like ABR, is expensive and time consuming. Also, it has an extremely high false-positive rate of 66% as reported by Galambos, Hicks, and Wilson (1982): 124 infants out of 188 identified by Crib-o-gram as having a hearing loss, had normal hearing.

The measurement of middle ear reflexes has also been used in the newborn nursery. An infant's hearing threshold may be predicted by the measurement of the acoustic reflexes, a method described by Jerger et al. (1974), and known as SPAR: Sensitivity Prediction from Acoustic Reflex. It has a low false-positive rate; 92 to 100% of subjects who were predicted to have normal hearing did have normal hearing (Keith, 1977; Tsappis, 1977; Hall, 1978). However, the primary problem with SPAR is that the clinician must have some cooperation from the subject. The reported results were obtained with adults and cooperative children. Impedance audiometry is difficult to do with infants because the clinician rarely has their complete cooperation. Sometimes the infant's crying and movement makes it impossible to test the infant at all.

Each of the approaches taken in the newborn nursery for the determination of hearing loss has certain problems. Therefore following any of these procedures, a second test method is warranted for serving as a reliability check. If an infant fails the high risk register, and/or ABR, the Crib-o-gram or SPAR, a second test approach seems justified for insuring the reliability of initial test findings. Additionally, if the equipment needed for newborn screening procedures is not available, the clinician must revert to another procedure available to assess the young infant's hearing before he/she reaches the age of 6 months, when conditioning audiometry (Visual Reinforcement Audiometry (VRA)) can be used.

BOA could be used as a drop back procedure for infant screening to establish those infants who have a hearing loss from the false-positives. However, the problem with BOA at this point is the range of normal responses. In order to make BOA more efficient, it is necessary to narrow the range of response level.

It is important that the clinician know what factors might have an effect on the infant's response. Eisenberg et al. (1964) investigated several factors including signal variables (complexity and duration), sequence of presentation, activity state of the infant, and age. Their results indicated that stimulus is the key factor in BOA. Based on the results, it seems necessary to determine if different stimuli can reduce the dispersion of normal responses in young infants.

Eisenberg et al. (1964) looked at four spectrally complex stimuli (drumbeat, whistle, striking sticks and crumpling onion skin paper) leaving several types of audiotory stimuli uninvestigated. Other investigators have used a variety of stimuli when testing young children by BOA (Hoversten and Moncur, 1969; Thompson and Thompson, 1972). These investigators demonstrated that speech is a good auditory stimulus and may be helpful in reducing the range of normal. There are other stimuli that need further investigation such as: complex noise, filtered complex noise, filtered speech, white noise, and filtered white noise. One purpose of this study was to investigate six stimuli (speech, filtered speech, white noise, filtered white noise, complex noise, filtered complex noise) to determine if they could reduce the normal reported range of responses, and make BOA a valid test for improving the accuracy of early identification of hearing loss in infants.

BOA thresholds improve with age because of maturation, but habituation to the stimuli can occur rapidly (Moore, Wilson and Thompson, 1977). Older infants tend to lose interest quickly and stop responding. However, when reinforcement is introduced into the test procedure, the older infant ". . . will respond long enough for determination of hearing sensitivity at various frequencies" (Hodgson, 1981). This procedure is known as visual reinforcement audiometry (VRA). Liden and Kankkunen (1969) reported that VRA could reliably evaluate infants from 6 to 8 months of age. Moore, Wilson and Thompson (1977) indicated that infant's response rates increase when reinforcement is utilized, but that VRA is age specific. It could not be used to evaluate infants younger than 5 months of age.

To continue a program of early assessment, an infant at risk for a hearing loss may first be evaluated with BOA before 6 months of age, and again with VRA once the infant reaches 6 months of age. Therefore, the second purpose of this study was to compare BOA and VRA methods using the same subjects. The third purpose of this study was to determine how the six stimuli breakdown in terms of mean intensity levels when reinforcement was added to the assessment procedures.

# CHAPTER II

# REVIEW OF LITERATURE

## Behavioral Observation Audiometry

Behavioral observation audiometry is a useful method of assessing the hearing of infants according to Thompson and Weber (1974). They investigated the responses of 190 infants and young children from 3 to 59 months in age. Speech and complex noise were utilized as stimuli. Two judges observed the infant's behavior for changes upon presentation of the stimulus.

> Each judge had a score sheet for each subject on which he could independently record a plus, zero, or a question mark after each presentation of a stimulus. . . . A response was defined by both judges scoring a plus or one scoring a plus and the other a question mark (Thompson and Weber, 1974).

A plus was scored if the judge observed specific changes in the infant's behavior such as localization toward the sound, looking up, verbal utterance, or eyeblink/whole body startle. Using this procedure they were able to obtain information that was ". . . sufficient to conclude that the infant's peripheral hearing status is at least grossly within normal limits . . ." (Thompson and Weber, 1974). Other studies have also successfully used a similar approach in their assessment of infants (Eisenberg et al., 1964; Mendel, 1968; Hoversten and Moncur, 1969; Ling, Ling, and Doehring, 1970; Thompson and Thompson, 1972).

Many factors can influence the results obtained in BOA. Eisenberg et al. (1964) investigated the following factors in their study: signal variables (complexity and duration), sequence of presentation, activity state of infant (deep sleep, light sleep, less than full wakefulness, alert), and age. One hundred seventy neonates were tested (34-42 weeks gestational period

> . . . four spectrally complex noisemaker stimuli, matched approximately for a sound pressure level (SPL) of 65 dB, and selected for specified frequency range and duration characteristics which were provided by: . . . (Eisenberg, et al., 1964).

1. drumbeat equal to a tone of 500-900 Hz, 300 msec. in duration;

2. crumpling of a fresh sheet of onionskin paper equal to white noise, 1.3 sec. in duration;

3. striking a pair of pierced wooden sticks equal to white noise, 200 msec. in duration;

4. toot of a small plastic whistle, equal to a tone of 4000-4500 Hz, 250 msec. in duration.

Each stimulus was presented five times in a random order for a total of 850 presentations for the 170 subjects. Three independent observers scored the responses as positive, questionable, or negative on the basis of the presence/absence of the following responses: motor response, eye response, arousal, or orientating quiet. Responses were counted as positive if there were two out of three agreements between the individual observers.

Their results indicated that complexity and duration of signal had the most effect on the responses to auditory stimulation. They found that a white noise with long duration (1.3 sec.) elicited the most responses (602 out of 850) and that a high frequency signal with a shorter duration (250 msec.) elicited the fewest responses (399 out of 850). As complexity and duration of the signal increased, more responses were elicited. White noise of 200 msec. duration elicited 511 responses out of 850, and a low frequency signal of 300 msec. duration elicited 561 responses out of 850. The sequence of stimuli presentation had no significant effect on the complexity of the response or its time characteristics. Infant state, however, did have an effect on the responses in that the number of responses varied systematically with activity state. The light sleep state produced the most responses because the percentage of motor responses was higher at this stage than the other stages.

As the Eisenberg et al. (1964) study has indicated, complexity and duration of the stimulus have the most effect on infant's responses. The different types of stimuli utilized most often in BOA vary in complexity and include pure tones, broadband noise, high pass noise, low pass noise, and speech. However, according to Eisenberg et al. (1964), the more complex the stimulus is, the more responses it elicits. Therefore an important factor to consider when using behavioral assessment is the type of stimulus. The outcome of the procedures can be influenced because an infant's response can vary as a function of test stimulus.

Hoversten and Moncur (1969) and Thompson and Thompson (1972) have demonstrated that infants respond most often to speech and the least often to pure tones. Hoversten and Moncur (1969) tested two groups: 21 3-month-old and 22 8-month-old infants with five different stimuli:

1. music: produced by a flute, 1450-3190 Hz;

2. speech: female voice with fundamental frequency of 174-638 Hz (Hi, oh-oh, mama mama);

3. pulsed 4000 Hz pure tone;

4. pulsed 500 Hz pure tone;

5. pulsed white noise.

Each stimulus was presented twice at four different intensity levels. Two observers independently scored the infant's responses. Any behavioral change was considered a response, but the observers had to agree on whether or not a response occurred and the type of response. The results obtained indicated that for both age groups, the speech stimulus elicited the most responses, followed by white noise, the 500 Hz pure tone, and music. Finally, the 4000 Hz pure tone elicited the fewest number of responses.

Thompson and Thompson (1972) based their study on the Hoversten and Moncur (1969) study. Their study's purpose was to determine if a good stimulus like speech (as indicated by Hoversten and Moncur, 1969), could be filtered and still maintain its effectiveness. Four other stimuli were used for comparison. They tested two groups: 15 7-12 month olds and 30 22-36 month olds with 5 different stimuli:

1. broadband white noise;

2. speech: Hi (child's name) look at me;

3. filtered speech: same as the speech stimulus but filtered above 2000 Hz;

4. filtered white noise: above 2000 Hz;

5. 3000 Hz pure tone.

Each stimulus was presented twice at four different intensity levels. Two independent observers scored the infant's responses. Obtained results were similar to those obtained by Hoversten and Moncur (1969). Speech obtained the most responses closely followed by filtered speech which had almost the same effectiveness as speech until lower hearing levels were reached. Broadband white noise was third followed by filtered white noise. As in the Hoversten and Moncur (1969) study, the high frequency pure tone elicited the fewest number of responses.

The results of these two studies demonstrated that a complex stimulus such as speech is the optimal stimulus to use in the behavioral assessment of infants. However, Coleman and Pelson (1977) have indicated that speech is not a good stimulus to use in BOA. Using 5 hearing impaired children, they averaged out a "typical sharply sloping high frequency hearing loss." This was compared with the best monaural threshold for the normal hearing population as specified by the American National Standards Institute (1969). To compare these averages with bandwidths and frequencies of speech, they were superimposed on a spectrographic analysis of a male voice saying "baseball." They also investigated other stimuli besides speech in the same manner. The two averages were superimposed on spectrographic analysis of a high pitched squeeze toy, a small brass bell and crinkled cellophane. They concluded that each of the stimuli, including speech, were not good stimuli for the assessment of the hearing of infants and children because of the poorly defined bandwidths and varied intensity levels. If speech is to be used as a stimulus, they suggested the use of high pass filtering of speech with ". . . a cutoff frequency variable up to at least 6000 Hz with a minimum slope of 24 dB per octave . . ." which would give it ". . . the frequency specificity of pure tones" (Coleman and Pelson, 1977). They indicated that this stimulus would give a more accurate picture of the infant's true hearing threshold.

The use of filtered speech is also advocated by the Thompson and Thompson (1972) study. They indicated that high pass filtered speech had almost the same effectiveness as speech until lower hearing levels were reached. They found that it had a response rate of 80% and support its use in behavioral assessment. However, Surr et al. (1981) have indicated that filtered speech stimuli cannot accurately determine the infant's hearing threshold. They tested 59 subjects aged 22 to 73 years in age. All the subjects had sloping hearing losses. They then averaged the pure tone and speech band thresholds at octave intervals of 250-4000 Hz. Their results indicated that

> . . . individual threshold differences from 1000 to 4000 Hz revealed that the speech band results underestimated the pure tone in excess of 20 dB in 10% of the thresholds . . . underestimation is markedly greater in the higher test frequencies. At 4000 Hz for example, speech band thresholds were in error by more than 20 dB in 64% of the cases and by more than 40 dB in 35% of the cases (Surr et al., 1981).

Even though their study was based on adult subjects, they concluded that use of filtered speech is not appropriate to use with infants and children because they display the same types of hearing loss as adults.

Block, Kenworthy and Wiley (1981) suggested the use of complex noise instead of speech-filtered speech in behavioral assessment because it has a band width that is likely to elicit more responses.

Complex noise generated by a computer ". . . has many desirable speech-like qualities without the apparent limitations . . ." (poorly defined bandwidth and variance in intensity) ". . . of speech and other stimuli." They tested 10 normal hearing adults aged 20 to 32 years using a computer generated multi-tone complex. "The complex consisted of equal amplitude frequencies at 60 Hz intervals across the frequency range of 540 to 1980 Hz." They also used white noise and speech noise as stimuli for comparison with the complex stimuli. The results indicated that the complex noise elicited lower detection thresholds than the speech noise or white noise and it provided ". . . a threshold estimate consistent with the estimate obtained with pure tones." Based on these results, complex noise might be considered a good stimulus to use in the behavioral assessment of infants (as with adults) because of its effectiveness in eliciting lower detection threshold levels.

Coleman and Pelson (1977) suggested the use of high-pass filtered complex noise instead of an unfiltered complex noise because it allows complete control of the stimulus parameters. Filtered complex noise, like filtered speech, has the ". . . frequency specificity of pure tones . . ." (Coleman and Pelson, 1977) which would give a more accurate picture of the infants true hearing threshold levels.

Several studies have indicated that infants respond more to complex stimuli than to any other stimuli when using behavioral assessment procedures (Eisenberg et al., 1964; Mendel, 1968; Eisenberg, 1969; Hoversten and Moncur, 1969; Ling, Ling and Doehring, 1970; Thompson and Thompson, 1972; Thompson and Weber, 1974; Coleman and Pelson, 1977). Therefore it would appear that complex stimuli (like speech, filtered speech, white noise, filtered white noise, complex noise, and filtered complex noise) would be the most appropriate stimuli for BOA in order to lower the range of normal responses and increase its accuracy in identifying infants with a hearing loss.

Visual Reinforcement Audiometry

To further assess the hearing of infants, the use of visual reinforcement audiometry (VRA) is supported by Moore, Wilson and Thompson (1977). They investigated the effect of visual reinforcement (three dimensional mechanical toy) on head turn responses of infants aged 4 to 11 months. Sixty infants were divided into control and experimental groups and then subdivided into three age groups, 4 months, 5 to 6 months, and 7 to 11 months. A 70 dB complex noise was used as a stimulus and was presented for 30 trials for each group.

Their results indicated that the two older groups of infants responded significantly more to visual reinforcement than to no reinforcement. They also found that there was no significant difference between the two groups of 4 month olds. The results indicated that with reinforcement the 7 to 11 month olds response rate was 100% as compared to the 33.3% response rate without reinforcement. The use of reinforcement with the 5 to 6 month olds was also appropriate as shown in the 83.3% response rate. Without reinforcement the response rate for that age group was only 16.6%. However, the results also indicated that reinforcement was not appropriate for infants 4 months of age who had a response range of 16.6% with or without reinforcement. Therefore, these results would indicate that VRA is appropriate for infants 5 months and older.

Other studies have indicated that visual reinforcement produced more responses than no reinforcement with older infants (Liden and Kankkunen, 1969; and Moore, Thompson and Thompson, 1975). Therefore it would appear that visual reinforcement audiometry is an appropriate measure in the assessment of infants 5 months and older.

# CHAPTER III

## METHODS AND PROCEDURES

The purpose of this study was to investigate the use of six complex stimuli (complex noise, filtered complex noise, white noise, filtered white noise, speech, filtered speech) in the following conditions: (1) to determine if one or more of the stimuli would reduce the normal range of responding in behavioral observation audiometry and make it a valid test for improving the accuracy of early identification of hearing loss in infants; (2) to compare the two methods (BOA and VRA) when using the same subjects; and (3) to determine how the six stimuli breakdown in terms of mean intensity levels when reinforcement was added to the assessment procedures.

### Subjects

Ten infants were selected from the birth announcements listed in the Knoxville newspaper. These infants were divided into 2 groups of 5 infants each: Group 1--2 to 4 month old infants, and Group 2--6 to 8 month old infants. Criteria for inclusion to this study were based on those established by Thompson and Weber (1974) in their study: normal development according to parental report, no unusual medical history, no known ear infection (at the time of testing), and no evidence of a cold on test day. "These criteria were applied to insure that the sample represented a population of infants . . . with normal hearing and development." To rule out the possibility of middle ear infection/problem at the time of testing, screening tympanograms were obtained on each infant. Only those infants with Type A tympanograms (± 100 mm $H_2O$) were accepted.

Stimuli

Six complex stimuli were selected for this study, including:

1. live speech: ByeByeByeByeBye;

2. filtered live speech: same as the speech stimulus but high pass filtered with a cut-off frequency set at 2000 Hz with a 48 dB per octave roll-off;

3. white noise: equal energy at all frequencies (limited by frequency response of the speaker);

4. filtered white noise: high pass filtered with a cut-off frequency set at 2000 Hz with a 48 dB per octave roll-off;

5. complex noise: composed of individual frequencies from 60 to 6000 Hz at 60 Hz intervals with equal energy at each frequency;

6. filtered complex noise: high pass filtered with a cut-off frequency set at 2000 Hz with a 48 dB per octave roll-off.

Two of the six stimuli (speech and filtered speech) were presented via live voice. However, variability of the stimulus presentation was minimized by careful monitoring of the VU meter. With the exception of white noise, the other five stimuli were monitored at 0 dB VU throughout the test session. Due to the physical limitations of the equipment, 0 dB could not be reached with the white noise stimulus. The highest VU meter reading possible for the white noise was -3 dB

VU, which was maintained throughout each test session. Two of the stimuli (complex noise and filtered complex noise) were recorded.

Instrumentation

A Grason-Stadler 1704 audiometer was used to deliver the stimuli through a speaker on the left side of the test room. The white noise was generated by a custom-made noise generator. The filtered white noise and filtered speech were the same two unfiltered stimuli passed through a Rockland Model 852 High/Lo filter set to 2000 Hz high pass with a 48 dB per octave roll-off. The two recorded stimuli were played on a TEAC 2340 channel stereo tape recorder.

An "and-gate" circuit was used for judging purposes in delivering reinforcement in the VRA condition. It was set for a 4-second observation interval and a 4-second reinforcement period. A block diagram for the instrumentation used in this study is shown in Figure 1.

All testing was done in a two room IAC test suite. Before testing the infants, it was necessary to determine 0 dB HTL for awareness of all six stimuli, which were then converted to sound pressure level. A suprathreshold level of 40 dB SL (re. 0 dB HTL awareness) was also measured to determine stimuli intensity at suprathreshold levels. The 0 dB HTL levels were established by obtaining soundfield thresholds on 8 normal hearing adults. Each subject was seated in the test room approximately 5 feet to the side of the left speaker. The stimuli were presented in a random order and threshold for each stimulus was defined as the lowest level that produced two out of three responses. The eight responses for each stimulus were averaged to

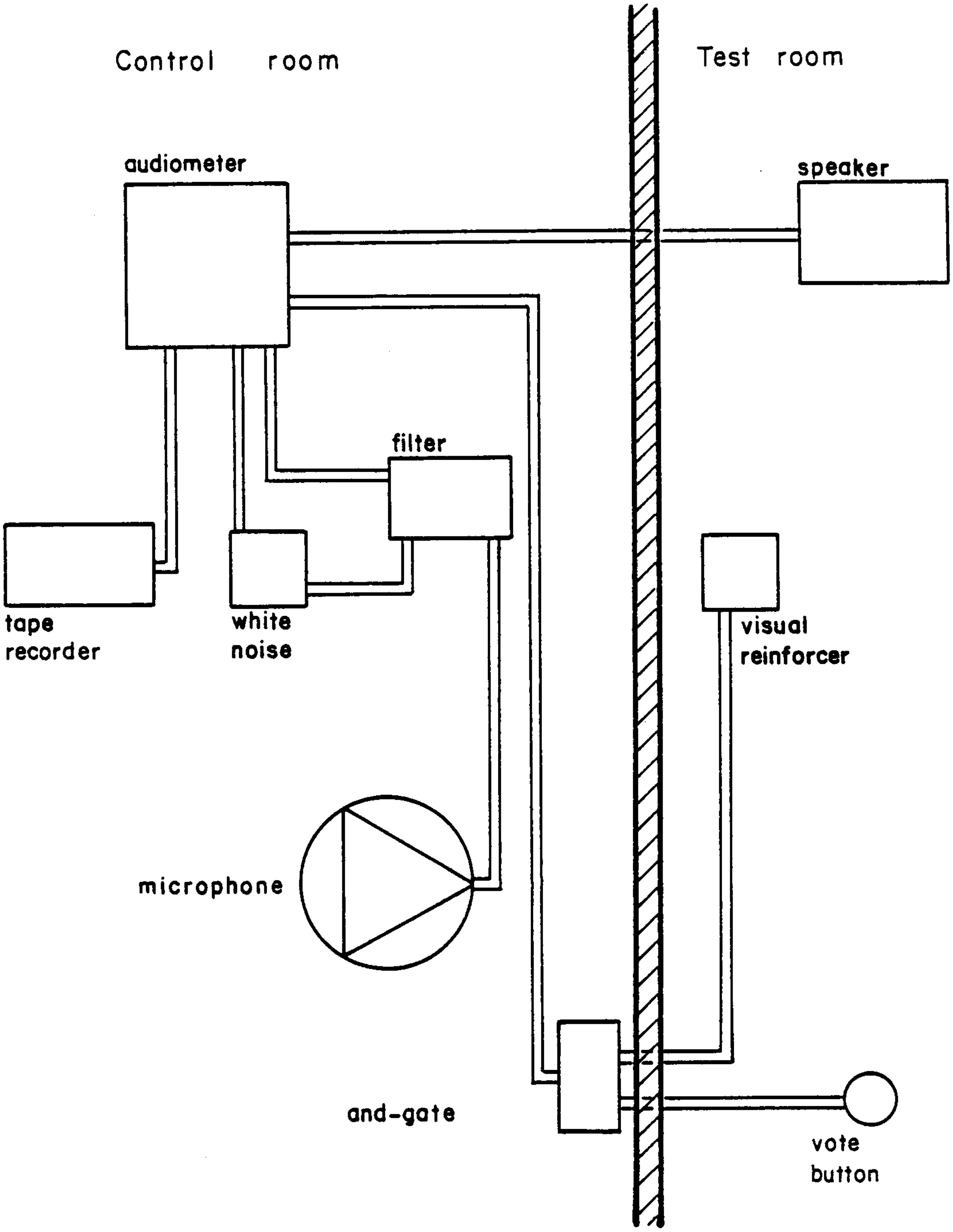


Figure 1. Block diagram of instrumentation utilized in the study.

determine the awareness level. A Bruel and Kjaer sound level meter (Type 2209) was used to determine the sound pressure level for the 0 dB HTL for each stimulus (see Table 1). Measures were made for both the BOA and the VRA conditions (see Figures 2 and 3).

## Test Procedures

Behavioral Observation Audiometry (BOA). For the BOA condition, Group 1 and Group 2 were tested by the same procedure. The infant was seated in his/her mother's lap. Both were seated between the two speakers, approximately 3 feet from the left speaker. To rule out the mother's participation, music through earphones was used as a masking stimulus. The music was played at a comfortable level but loud enough to prevent the mother from hearing the stimulus presentations.

Two examiners were present for the testing. Both were located in the control room: one presenting the stimuli and acting as a judge and the second acting only as a judge. Both examiners were trained observers in infant's behavior to sound, and were familiar with pediatric assessment.

The duration of each stimulus was approximately 2 seconds with the interstimulus interval lasting no longer than 60 seconds depending on the state of the infant. The stimuli were presented in a random manner and only when the infant was relatively quiet (no crying or moving about). The intensity of the stimuli was varied with the first stimulus presentation at 30 dB HTL. The stimulus was increased in 20 dB steps until a response was obtained and then decreased by 20 dB until there was no response and then increased again 10 dB steps

Table 1. Sound Pressure Levels (re. 0.0002 dynes/cm$^2$) for 0 dB HTL for Each Stimulus in the BOA and VRA Conditions.

| Stimulus | BOA: *SPL = 0 dB HTL | VRA: *SPL = 0 dB HTL |
|---|---|---|
| Complex Noise | 7 | 3 |
| Filtered Complex Noise | 17.5 | 12.5 |
| White Noise | 7.5 | 3 |
| Filtered White Noise | 10 | 4 |
| Speech | 22 | 23.5 |
| Filtered Speech | 21 | 17 |

*All SPL measures were taken with the "A" weighing scale of the sound level meter.

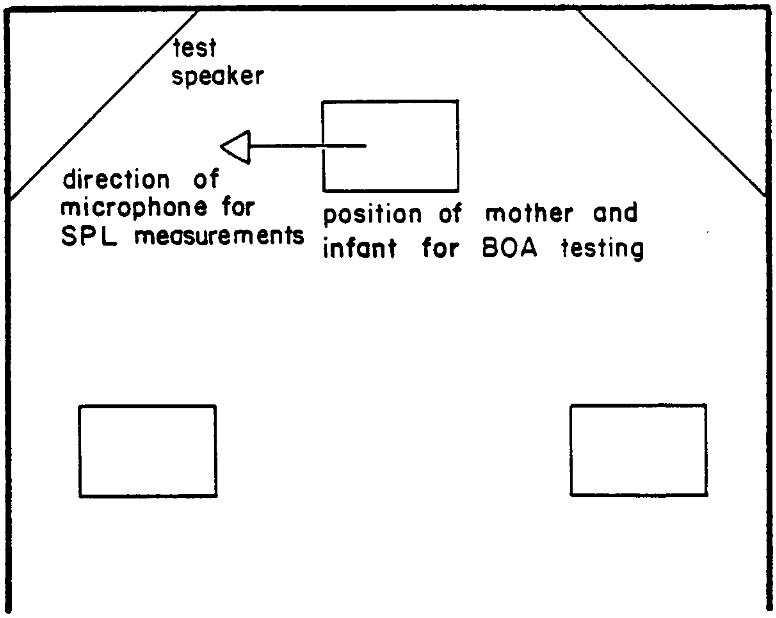


Figure 2. Room setup for the BOA condition for SPL measurements and infant testing.

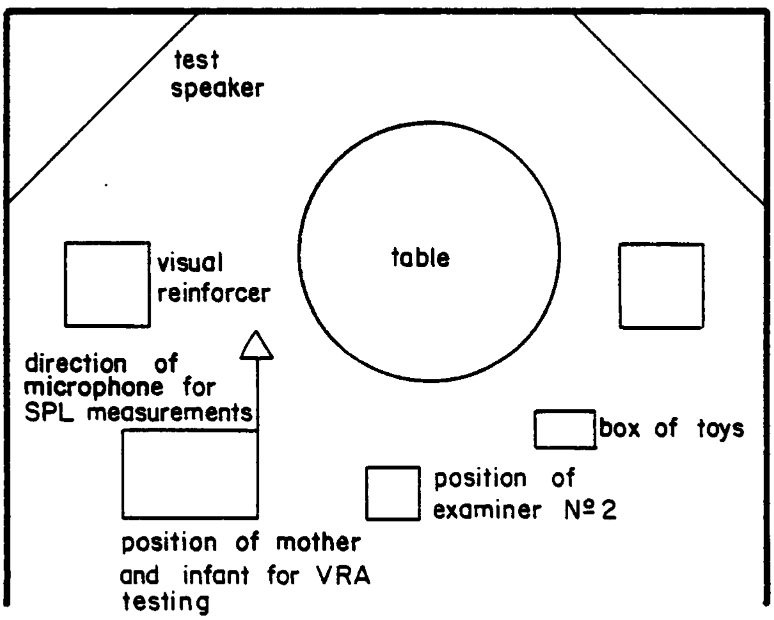


Figure 3. Room setup for the VRA condition for SPL measurements and infant testing.

until a response was obtained. These procedures were repeated for a second and third trial for each stimulus. Both judges observed the infant for responses and had to be in agreement before each threshold trial was accepted. Examiners monitored the infant's behavior before, during and after the presentation of stimulus. Accepted responses were motor responses (Moro, Quasi-Moro), eye blink, arousal, orienting quiet (Eisenberg, et al., 1964) and localization or head turn for the infants in Group 2. Examiners could vote: "yes, there is a response," "no, there is no response," "questionable." Both judges had to vote "yes" before the stimulus threshold trial was accepted.

Visual Reinforcement Audiometry (VRA). Group 2 was tested in the VRA condition upon completion of BOA testing. The infant was seated in his/her mother's lap. Both were seated approximately 5 feet from the side of the left speaker. The visual reinforcer (mechanical elephant in a smoked plexiglass box) was located to the infant's left, approximately 2 feet away. In order to be rewarded, the infant was required to turn his/her head to the left upon presentation of a stimulus. The head turn was the only acceptable response in the VRA condition.

One examiner was located in the control room to operate the audiometer and the other was located in the test room to occupy the infant with noiseless toys. The examiner in the test room with the infant was kept "blind" to the presentation of the stimulus for judging purposes. He was masked in the same manner as the mother in the BOA procedures. When he observed what he thought was a response to a stimulus, he pressed a vote button which was connected to an "and-gate" with a 4-second observation interval. If a head turn occurred upon presentation of a stimulus, the examiner in a control room also voted and the infant was rewarded for 4 seconds.

Before actual testing began, it was necessary to condition the infant for the head turn response. To condition the infant, the stimulus (presented at 50 dB HTL) was paired with the visual stimulus until the infant spontaneously responded 3 times in a row. The examiner then moved to threshold procedures. When the infant responded, the stimulus was decreased in 20 dB steps until no response was observed. The stimulus was then increased to 10 dB steps until the infant responded. The infant was rewarded for each response. Threshold was defined as the lowest level that produced two out of three responses. These procedures were repeated for each stimulus.

# CHAPTER IV

## RESULTS

All data in the study are presented in SPL because of the lack of calibration standards for the stimuli in a controlled sound field. However, the data are also presented in HTL for comparison. All data are presented in corrected form, based on the 0 dB HTL established from the calibration means from adult values (see Table 2).

The threshold means in dB SPL for each stimulus for Group 1 and Group 2 in the BOA condition and Group 2 in the VRA condition are shown in Table 3. The threshold means in dB HTL are shown in Table 4. The ranges of responses for each stimulus for Group 1 and Group 2 in the BOA condition are shown in Figures 4 and 5 respectively. The range of response for each stimulus for Group 2 in the VRA condition is shown in Figure 6. The actual calibration and test data in dB SPL and db HTL are shown in Appendices A, B, C, D, and E.

The mean intensity levels for eliciting responses in dB SPL for Group 1 and Group 2 in the BOA condition and Group 2 in the VRA condition are shown in Figure 7. The mean intensity levels for eliciting responses in dB HTL are shown in Figure 8. As noted in Figures 7 and 8, the mean intensity level for each stimulus shifts when the data are converted from SPL to HTL. This is due to the fact that each stimulus has a set amount of SPL built into the attenuator setting for 0 dB HTL, and the amount of SPL for each stimulus varies.

Table 2. Mean 0 dB HTL and Correction Value for Each Stimulus Based on Data Obtained from Eight Normal Hearing Adults.

| Stimulus | Mean 0 dB HTL | Correction Value |
|---|---|---|
| Complex Noise | 15 | -15 |
| Filtered Complex Noise | 5 | -5 |
| White Noise | 15 | -15 |
| Filtered White Noise | 15 | -15 |
| Speech | -5 | +5 |
| Filtered Speech | 0 | 0 |

Table 3. Mean Intensity Levels in dB SPL for Each Stimulus for Group 1 and Group 2 in the BOA Condition and for Group 2 in the VRA Condition.

| | | Stimulus | | | | | |
|---|---|---|---|---|---|---|---|
| | | CN | FCN | WN | FWN | Sp. | F.Sp. |
| Group 1: | BOA | 56 | 70.5 | 68.5 | 69 | 99 | 91 |
| Group 2: | BOA | 38 | 54.5 | 50.5 | 37.5 | 63 | 71 |
| Group 2: | VRA | 4 | 25 | 0 | 11 | 51 | 27 |

Note: See page ix for List of Abbreviations.

Table 4. Mean Intensity Levels in dB HTL for Each Stimulus for Group 1 and Group 2 in the BOA Condition and for Group 2 in the VRA Condition.

| | | Stimulus | | | | | |
|---|---|---|---|---|---|---|---|
| | | CN | FCN | WN | FWN | Sp. | F.Sp. |
| Group 1: | BOA | 49 | 53 | 57 | 59 | 77 | 70 |
| Group 2: | BOA | 33 | 37 | 43 | 27.5 | 41 | 50 |
| Group 2: | VRA | 1 | 12.5 | -3 | 7 | 27.5 | 10 |

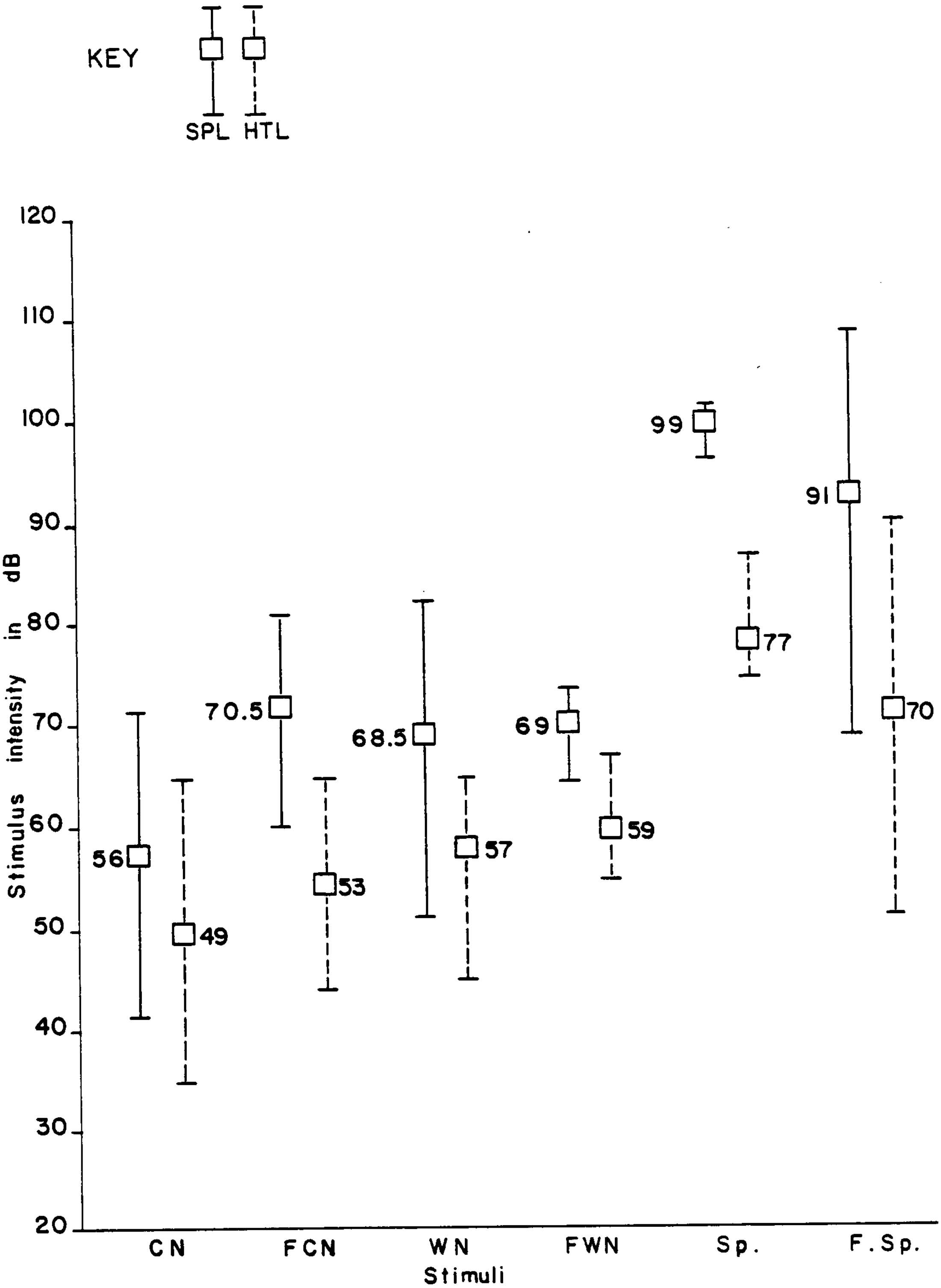


Figure 4. Threshold ranges in dB SPL and dB HTL for each stimulus in Group 1 for the BOA condition.

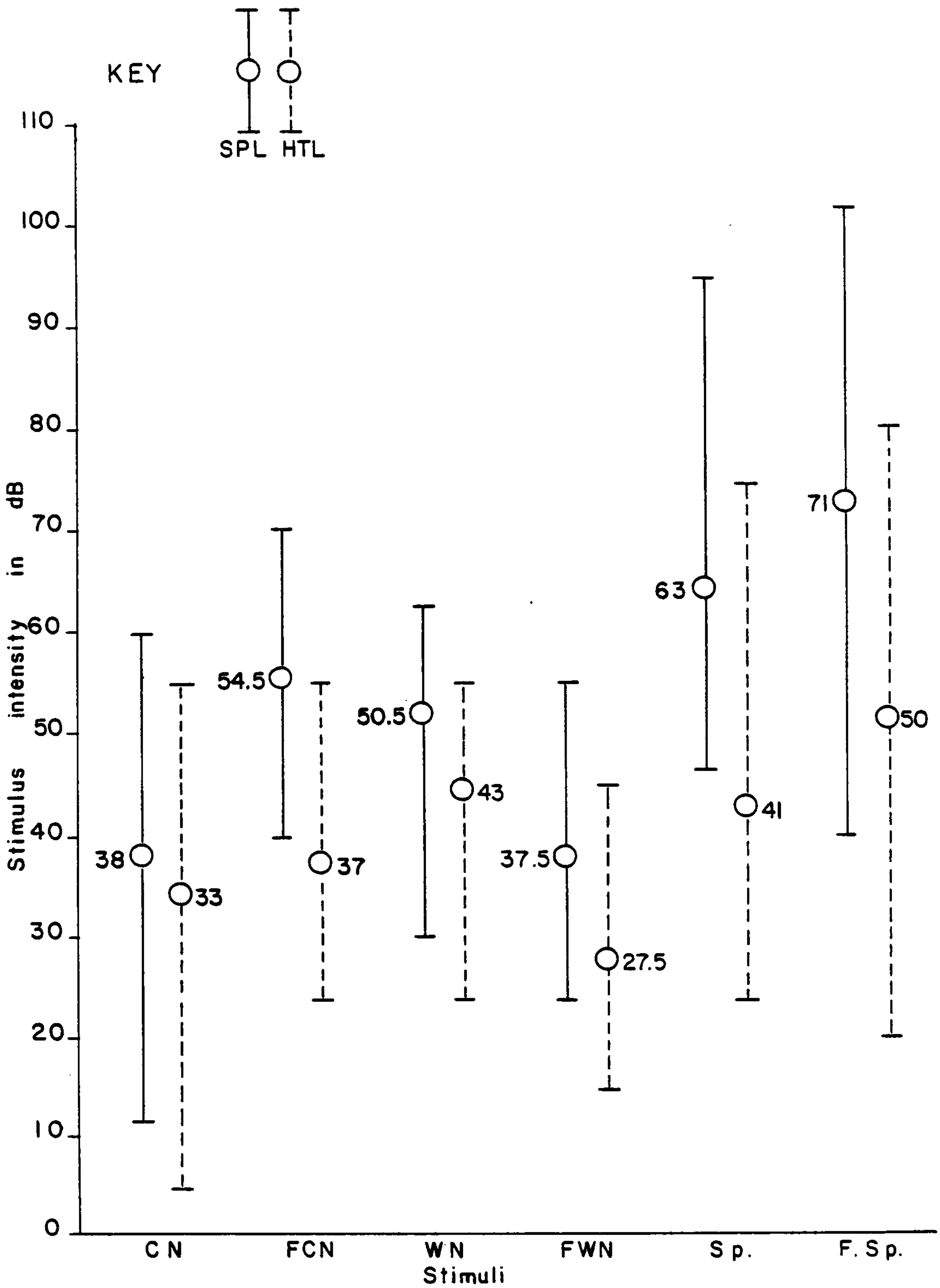


Figure 5. Threshold ranges in dB SPL and db HTL for each stimulus in Group 2 for the BOA condition.

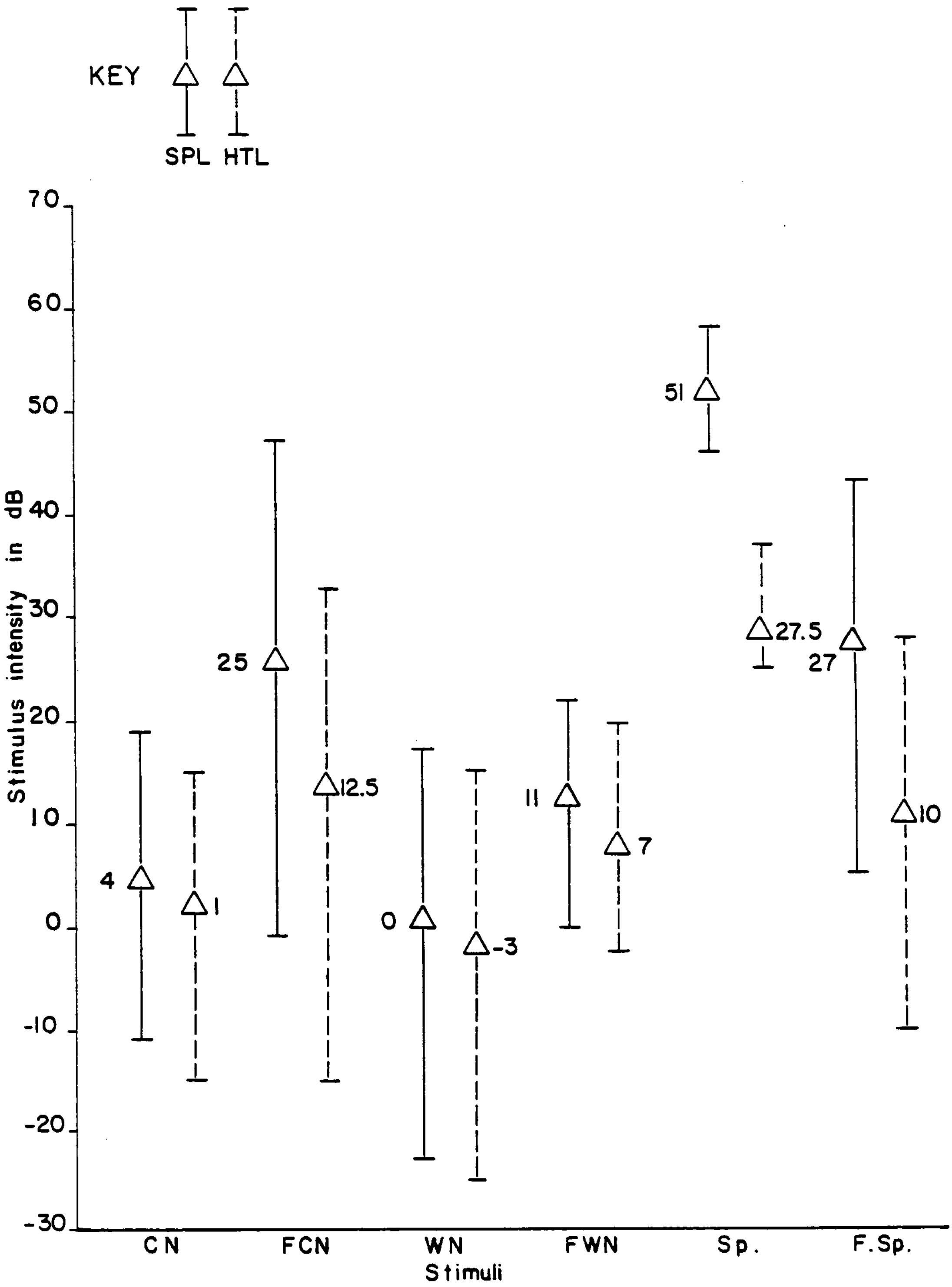


Figure 6. Threshold ranges in dB SPL and dB HTL for each stimulus in Group 2 for the VRA condition.

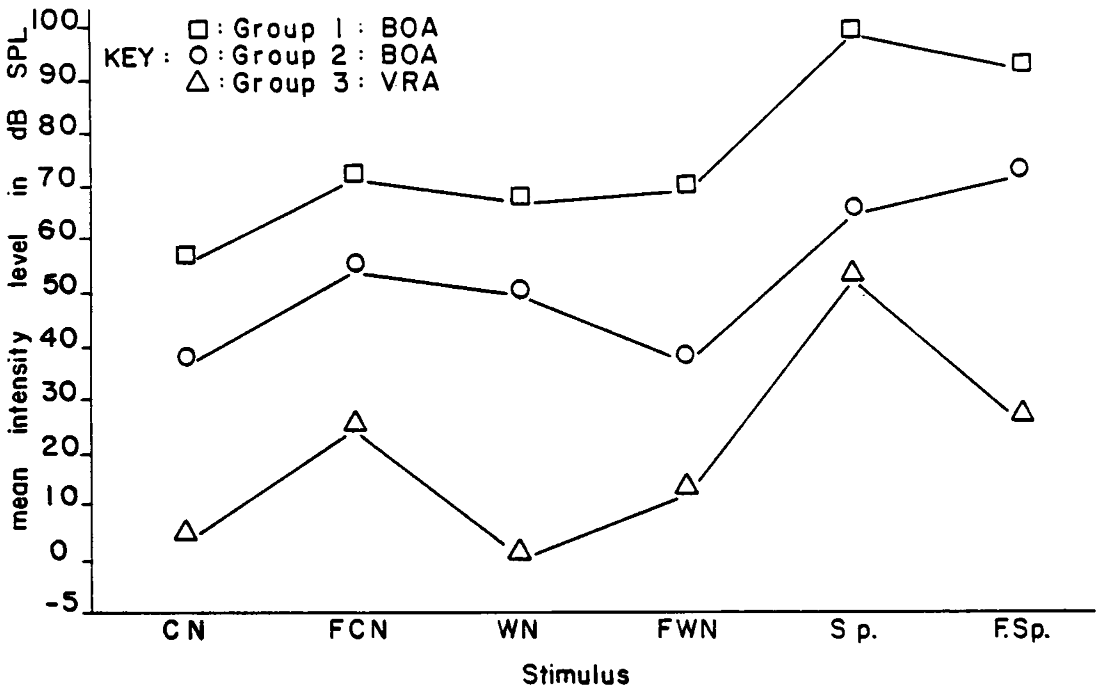


Figure 7. Mean intensity level in dB SPL for eliciting responses for six stimuli in Groups 1 and 2 for the BOA condition and in Group 2 in the VRA condition.

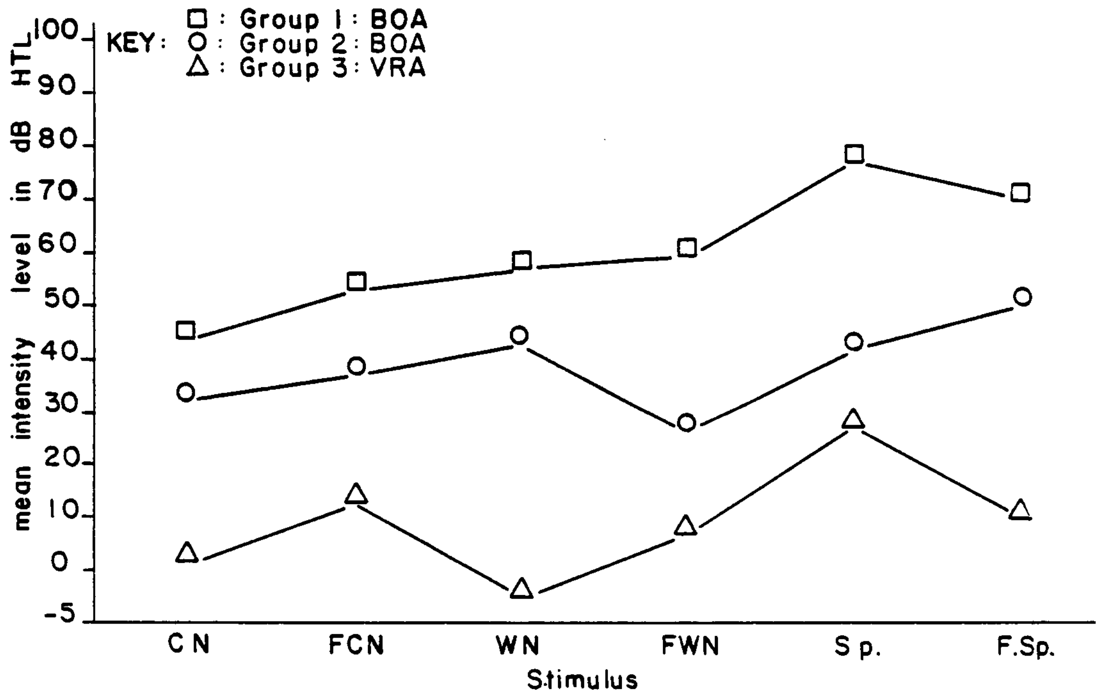


Figure 8. Mean intensity level in dB HTL for eliciting responses for the six stimuli in Groups 1 and 2 for the BOA condition and in Group 2 in the VRA condition.

# CHAPTER V

## DISCUSSION

For Group 1 (2 to 4 month olds), the range of responding in BOA is not greatly reduced by any of the six stimuli. There is also a wide range of responding in BOA for Group 2 (6 to 8 month olds). These results are consistent with the response ranges stated in the Thompson and Weber study in 1974. When testing with the BOA condition, it was noted that the infants in Group 2 habituated to the stimulus presentations quickly which contributed to the wide range in responding. However, the mean intensity levels of each stimulus are consistently lower for Group 2 than Group 1. This is supported by Hoversten and Moncur (1969) and Thompson and Weber (1974) who demonstrated that as age increases, the intensity level necessary to elicit behavioral responses decreases.

Of the two conditions, VRA produces better mean thresholds and smaller ranges. These results support those found in the Moore, Wilson, and Thompson (1977) study which demonstrated mean thresholds similar to adult values and ranges within one measurement step size when using visual reinforcement with infants 5 months and older. The ranges in the present study are wider than one measurement step size which could be due to the possibility of fatigue contaminating the data. However, visual reinforcement reduces habituation allowing the audiologist to keep the infant's attention long enough to complete an audiometric evaluation and obtain thresholds very close to adults. As indicated by Moore, Thompson, and Thompson (1975), a visual stimulus reinforces auditory localization behavior, and once conditioned to respond the infant will continue to respond to auditory stimuli as long as he/she is rewarded with the visual stimuli. The results from this study demonstrated that the use of VRA reduces the range of responding and produces better mean thresholds as shown in Figure 6 and 7.

However, as indicated by Moore, Wilson, and Thompson (1977) VRA is not appropriate for infants aged 4 months and younger. When comparing the differences between the two groups in the BOA condition with the responses in the VRA condition, it can be assumed that the responses obtained with Group 1 are the best that one can do with this age group. Visual reinforcement is inappropriate because infants below 5 months of age cannot generally be conditioned for VRA because they lack the head control required for the head turn response. Thus the wide range of responses obtained in BOA are typical and apparently cannot be reduced.

The results from this study support BOA as a screening procedure. When comparing the results of Group 2--BOA and Group 2--VRA large differences between the two mean intensity levels are noted. These results are obtained on the same subjects but in different conditions, BOA first and then VRA. The differences are due to the type of assessment procedure and the type of response it utilizes. BOA utilizes reflexive responses whereas VRA utilizes a conditioned response. Reflexive responses occur at suprathreshold levels but conditioned responses can occur at threshold or near-threshold levels. Once conditioned, an infant will continue to respond as long as he/she is reinforced for the response during the test session (no longer than 45 minutes). On the other hand, with Group 2 in the BOA condition, the responses occurred only at suprathreshold levels--that is, signal levels loud enough for the stimulus to be novel--and then the infants habituated quickly making it difficult to obtain threshold measurements. With Group 1, it is difficult to condition the infants to respond, thus reflexive responses are the responses which can be accepted for this age group in this procedure. But as indicated by Thompson and Weber (1974), one can obtain enough information utilizing BOA to determine whether or not the infant's hearing status is grossly within normal limits.

Visual reinforcement produces more localization responses due to operant conditioning and the application of reinforcement. Therefore, habituation can be reduced and the infant's attention held long enough to determine his/her hearing sensitivity. When comparing the BOA results of Group 2 with the VRA results of the same group, large differences are noted (see Figure 7, page 30, and Table 3, page 26). For example, with complex noise in the BOA condition, the mean intensity level for Group 2 is 38 dB as compared to the VRA mean intensity level for Group 2 which is 4 dB. This is a difference of 34 dB and is a good example of suprathreshold measures versus threshold measures. The infants in Group 2 were old enough for the use of VRA, and as these results and Moore, Wilson, and Thompson (1977) results suggested, VRA is a more appropriate method of assessing infants above the age of 4 months as opposed to BOA.

Even though BOA is a suprathreshold measure, it is one of the few readily available assessment procedures for infants in the birth to 4 month age range. None of the stimuli employed lowered the range of responding to a normal range, but the type of stimulus utilized is important and does effect the infants response as shown by the breakdown between the stimuli for the two groups. Eisenberg et al. (1964), Hoversten and Moncur (1969), and Thompson and Thompson (1972) have also indicated that the type of stimulus does have an effect on the infant's response to auditory stimulation. Infants demonstrate better thresholds for some types of stimuli over others. For the two groups in the BOA condition there is a large breakdown between the mean intensity level for the six stimuli. For Group 1, complex noise ranked first (56 dB) and speech ranked last (99 dB). For Group 2, filtered white noise (37.5 dB) and complex noise (38 dB) ranked first and filtered speech ranked last (71 dB). The results obtained with complex noise support those of Block, Kenworthy, and Wiley (1981). They reported that complex noise is the optimal stimulus to use instead of speech in behavioral assessment because it is more alerting stimulus and has a bandwidth that is likely to elicit more responses. By using complex noise, they stated that one can ". . . maximize the likelihood of sampling that point in the audiometric configuration that is the most sensitive."

On the other hand, speech is considered by some investigators (Hoversten and Moncur, 1969; and Thompson and Thompson, 1972) to be the optimal stimulus to use. However, the results of this study indicate that speech/filtered speech ranked last with high mean intensity levels, suggesting that more intensity had to be present before the infant responded. These results support Coleman and Pelson (1977), and Block, Kenworthy, and Wiley (1981). Both studies reported that speech is not a good stimuli to use in the assessment of infants because they considered it to be a highly variable stimulus with poorly defined bandwidths and varied levels of intensity.

The results obtained with filtered speech also support the findings of Surr, et al. (1981). They indicated that filtered speech can markedly underestimate the subject's hearing sensitivity. In this study, when comparing the filtered speech stimulus with the other non-speech stimuli, the filtered speech underestimated the infant's hearing sensitivity by 20.5 to 35 dB SPL for Group 1 (based on mean intensity levels).

Coleman and Pelson (1977) suggested the use of high pass filtered speech as an optimal stimulus as opposed to speech. They indicated that high pass filtered speech would give a more accurate picture of the infant's true hearing threshold. However, this study has indicated that filtered speech gives an inaccurate picture of the infant's hearing sensitivity when compared to the other stimuli.

For the other three non-speech stimuli (filtered complex noise, white noise, filtered white noise) besides complex noise, the mean intensity levels are approximately the same (1.5 to 2 dB variation) for Group 1. When compared to complex noise there is a variation of 12.5 to 14.5 dB. Based on one measurement step of 10 dB in this study, there appears to be a clinical difference between complex noise and the three non-speech stimuli.

As Eisenberg et al. (1964) reported, the type of stimulus utilized in the assessment of infants is important. Therefore, based on the mean intensity levels of Group 1, the optimal stimulus to use in BOA is complex noise. Complex noise appears to be a more alerting and novel stimulus as indicated by Thompson and Weber (1974), and Block, Kenworthy, and Wiley (1981). However, complex noise has a bandwidth (60 to 6000 Hz) which might not detect a high frequency sensorineural hearing loss. As Coleman and Pelson (1977) have indicated, a high pass filtered stimulus appears to be more appropriate than an unfiltered stimulus in detecting that type of loss. Therefore, the use of a high pass filtered stimulus is necessary in behavioral assessment. Filtered white noise (69 dB) and filtered complex noise (70.5 dB) have better mean intensity levels than filtered speech (91 dB) based on the mean intensity levels of Group 1. There is on a 1.5 dB difference between the two stimuli, but the filtered white noise has a smaller range of response than the filtered complex noise. Based on this data, filtered white noise as well as complex noise should be used in behavioral assessment to obtain an accurate measure of the infant's hearing ability (low, mid, and high frequency hearing).

The mean intensity levels of Group 2 in the BOA condition are not utilized in this conclusion because they are a different age range from Group 1 and habituation to the stimulus is an important factor due to maturation. The clinician can quickly lose the infant's attention when he/she habituates to the stimulus and then it is easy to obtain inaccurate measures of the infant's hearing ability. BOA is not the procedure of choice after four to five months of age.

Therefore, the conclusion that complex noise is the optimal stimulus to utilize in BOA was based on the group whose age is appropriate for BOA.

With VRA, the breakdown of stimuli are not important. In all cases, the infant's hearing sensitivity was considered within normal limits (0 to 25 dB HTL). In operant conditioning, the reward is more important than the stimulus. As long as the infant is rewarded with the visual stimulus for his/her response, he/she will respond long enough to complete an audiometric evaluation (approximately 45 to 60 minutes). With that procedure it is possible to obtain thresholds very close to adults. Matkin and Thomas (1974) indicated that the "minimal response level" (threshold) improves with age and then reaches a plateau at 23 months of age. Adult norms are never reached. As the infant gets older, ability to attend to the stimulus and motivation increases along with his/her physiologic development, therefore different audiometric measures may be utilized. Moore, Wilson, and Thompson (1977) indicated that reinforcement (VRA) produces more responses than no reinforcement (BOA). Thompson and Thompson (1972) indicated that play audiometry (30 months to 4 years old) produces more responses than the use of visual reinforcement. As indicated by these studies, the subject's ability to respond and attend to the stimulus increases as he/she gets older. Therefore, it is probably not possible to obtain adult thresholds on infants in the VRA condition due to motivation, attention and ability to respond. However, adult and infant threshold differences tend not to exceed 10 dB.

Finally, in the assessment of infants in sound field, it is suggested that all data be reported in dB SPL due to the lack of stimuli calibration standards in sound field. These must be established for each individual test environment. The results can vary from site-to-site. The use of HTL can be misleading because the amount of SPL present in a stimulus can differ from that of another stimulus necessary to reach 0 dB HTL. Therefore, for the sake of clarity, it is suggested that all data in the assessment of infants be reported in dB SPL.

# CHAPTER VI

## SUMMARY AND CONCLUSION

The purpose of this study was to investigate the use of six complex stimuli (complex noise, filtered complex noise, white noise, filtered white noise, speech, filtered speech) in the following conditions: (1) to determine if one or more of the stimuli could reduce the reported normal range of responding in behavioral observation audiometry and make it a valid test for improving the accuracy of early identification of hearing loss in infants; (2) to compare the two methods (BOA and VRA) when using the same subjects; and (3) to determine how the six stimuli breakdown in terms of mean intensity levels when reinforcement was added to the assessment procedures.

Ten infants were divided into two groups: Group 1 (2 to 4 month olds) and Group 2 (6 to 8 month olds). Group 1 was tested in the BOA condition with the six stimuli and Group 2 was tested in the BOA condition and VRA condition with the same six stimuli.

Results indicated the same large range which has been reported to BOA, thus this dispersion cannot be further reduced because infants below 5 months of age cannot be conditioned to respond. Visual reinforcement reduced the response thresholds but was not appropriate for infants below 5 months of age. Therefore, it was concluded that the wide response ranges obtained in BOA were typical. BOA should remain a screening procedure.

As stated earlier, visual reinforcement reduced response thresholds for infants 5 months and older. Comparison of the BOA and VRA mean thresholds supported the use of visual reinforcement with the appropriate age range.

It can be concluded that early assessment of an infant should include BOA and VRA at the appropriate ages. BOA can provide enough information to determine if the infant's hearing status was grossly within normal limits. Once the infant reached the age where visual reinforcement can be utilized, thresholds can be obtained.

The stimulus type was the important factor in BOA. As the results indicated, the type of stimulus utilized effected the infant's response. Unfiltered complex noise appeared to be the optimal stimulus in terms mean intensity levels in eliciting responses in the BOA condition. However, high frequency hearing loss may not be detected by complex noise alone. Therefore, high pass filtered white noise appeared to be an optimal stimulus to use in the high frequency assessment of an infant's hearing abilities based on the results of this study.

The visual reinforcement was the primary factor in influencing results, followed by stimulus type which showed a minor effect. As long as the infant was rewarded for his/her responses, he/she continued to respond long enough to complete an audiometric evaluation (approximately 45 to 60 minutes) with thresholds near adult norms.

Further research investigating the use of complex noise and other complex stimuli are suggested so that the procedures of early assessment of an infant's hearing may be further improved and enhanced.

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## LIST OF REFERENCES


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# APPENDICES

# APPENDIX A

Table A-1. Calibration Data in dB SPL for Each Stimulus for the Eight Adults.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| A | 3 | 12.5 | 3 | 4 | 18.5 | 17 |
| B | 3 | 12.5 | 3 | 4 | 23.5 | 17 |
| C | 3 | 7.5 | 3 | 4 | 18.5 | 12 |
| D | 8 | 12.5 | 8 | 9 | 33.5 | 17 |
| E | 3 | 12.5 | 3 | -1 | 18.5 | 17 |
| F | 8 | 7.5 | 3 | 4 | 28.5 | 17 |
| G | -2 | 12.5 | 3 | 4 | 28.5 | 17 |
| H | -2 | 7.5 | -2 | -1 | 23.5 | 17 |

Table A-2. Calibration Data in dB HTL for Each Stimulus for the Eight Adults.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| A | 0 | 0 | 0 | 0 | -5 | 0 |
| B | 0 | 0 | 0 | 0 | 0 | 0 |
| C | 0 | -5 | 0 | 0 | -5 | -5 |
| D | 5 | 0 | 5 | 5 | 10 | 0 |
| E | 0 | 0 | 0 | -5 | -5 | 0 |
| F | 5 | -5 | 0 | 0 | 5 | 0 |
| G | -5 | 0 | 0 | 0 | 5 | 0 |
| H | -5 | -5 | -5 | -5 | 0 | 0 |

# APPENDIX B

Table A-3. Calibration Mean in dB SPL and dB HTL for Each Stimulus.

| Stimulus | SPL | HTL |
|---|---|---|
| Complex Noise | 3 | 0 |
| Filtered Complex Noise | 10.6 | -1.8 |
| White Noise | 3 | 0 |
| Filtered White Noise | 3.3 | -0.6 |
| Speech | 24.1 | 0.6 |
| Filtered Speech | 16.3 | -0.6 |

APPENDIX C

Table A-4. Threshold Data in dB SPL for Each Stimulus in Group 1 for the BOA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 1 | 42 | 62.5 | 52.5 | 65 | 97 | 71 |
| 2 | 52 | 72.5 | 62.5 | 65 | 97 | 71 |
| 5 | 52 | 82.5 | 62.5 | 75 | 97 | 111 |
| 6 | 72 | 62.5 | 82.5 | 75 | 97 | 91 |
| 7 | 62 | 72.5 | 82.5 | 65 | 107 | 111 |

Table A-5. Threshold Data in dB HTL for Each Stimulus in Group 1 for the BOA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 1 | 35 | 45 | 45 | 55 | 75 | 50 |
| 2 | 45 | 55 | 55 | 55 | 75 | 50 |
| 5 | 45 | 65 | 55 | 65 | 75 | 90 |
| 6 | 65 | 45 | 65 | 65 | 75 | 70 |
| 7 | 55 | 55 | 65 | 55 | 85 | 90 |

APPENDIX D

Table A-6. Threshold Data in dB SPL for Each Stimulus in Group 2 for the BOA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 3 | 12 | 62.5 | 62.5 | 55 | 57 | 41 |
| 4 | 62 | 72.5 | 52.5 | 25 | 57 | 91 |
| 8 | 62 | 52.5 | 62.5 | -- | 47 | 71 |
| 9 | 32 | 42.5 | 42.5 | 45 | 97 | 101 |
| 10 | 22 | 42.5 | 32.5 | 25 | 57 | 51 |

Table A-7. Threshold Data in dB HTL for Each Stimulus in Group 2 for the BOA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 3 | 5 | 45 | 55 | 45 | 35 | 20 |
| 4 | 55 | 55 | 45 | 15 | 35 | 70 |
| 8 | 55 | 35 | 55 | -- | 25 | 50 |
| 9 | 35 | 25 | 35 | 35 | 75 | 80 |
| 10 | 15 | 25 | 25 | 15 | 35 | 30 |

APPENDIX E

Table A-8. Threshold Data in dB SPL for Each Stimulus in Group 2 for the VRA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 3 | 18 | 47.5 | 8 | 9 | 48.5 | 27 |
| 4 | -12 | -2.5 | -22 | -1 | 48.5 | 7 |
| 8 | -2 | 37.5 | 18 | 19 | 48.5 | 37 |
| 9 | -2 | -- | 18 | 9 | -- | 47 |
| 10 | 18 | 17.5 | -22 | 19 | 58.5 | 17 |

Table A-9. Threshold Data in dB HTL for Each Stimulus in Group 2 for the VRA Condition.

| Subject | Stimulus | | | | | |
|---|---|---|---|---|---|---|
| | CN | FCN | WN | FWN | Sp. | F.Sp. |
| 3 | 15 | 35 | 5 | 5 | 25 | 10 |
| 4 | -15 | -15 | -25 | -5 | 25 | -10 |
| 8 | -5 | 25 | 15 | 15 | 25 | 20 |
| 9 | -5 | -- | 15 | 5 | -- | 30 |
| 10 | 15 | 5 | -25 | 15 | 35 | 0 |

VITA

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