AUDITORY THRESHOLD SHIFTS AS A FUNCTION OF REINFORCER CONSUMPTION

by

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Chapter 1

INTRODUCTION

In recent years, audiologists have been interested in the development of a reliable method for testing threshold in the difficult-to-test population, which includes the severely mentally retarded, and the very young child. A testing program which has been reported as being successful in obtaining reliable audiometric data with the mentally retarded population which were previously considered untestable by other procedures relies on operant methodology. Extensive reviews of the literature concerned with the use of these operant procedures can be found elsewhere. (Fulton and Lloyd, 1969; Fulton, 1972; Reid, 1969; Volkland, 1972) This operant procedure consists of interrelated phases based on the structuring of positively reinforcing contingencies. The initial training involves teaching the subject to respond to a discriminative stimulus (i.e. the interval when the tone is presented.) If the subject responds when the tone is not on, his response delays the onset of the next discriminative stimulus. After each response in the presence of the tone, a reinforcement is immediately delivered. The reinforcers utilixed in this procedure are food items, such as candy and cereals. Once the behavior is established, the subject is considered trained if he responds to 90 percent of the tone presentations and no more then 10 percent of the time the tone is not present. Threshold testing is then initiated. The procedure used consists of the descending method described by Carhart-Jerger (1959) with the continuation of reinforcement for each response made in the presence of the tone.

In the process of conducting research utilizing operant procedures with normal two year olds (Nowles, 1971), a certain phenomenon was noted. One of the researchers[1] found that her threshold shifted approximately 10 dB from her quiet threshold when she was consuming the reinforcer used in the study (candy and cereal). This observation indicated that further research in the area of reinforcer consumption might be of some importance. This report is concerned with the effects that immediate consumption of the reinforcer has on pure tone thresholds.

Reinforcer consumption has not been systematically investigated during audiological assessments with the difficult-to-test population. The purpose of this study, then, is to establish whether there is a significant threshold shift when consuming the reinforcer, and if there is, to determine when it occurs and approximately to what degree it occurs.

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[1] Dorothy Wallace

CHAPTER 2

EXPERIMENT I

Experiment I was concerned with determining effects of several consumitory behaviors (i.e., chewing M & M's, cereal, and gum) on Bekesy type threshold tracings. This procedure has the advantage of permitting continuous recordings of threshold data. A baseline threshold was obtained in quiet and at two masking levels, 10 and 20 dB effective masking. In each condition the subject was instructed to consume a specified item while continuing to trace his threshold. This procedure was repeated for each of the seven test frequencies to determine if threshold shifts are specific to certain frequencies. The listening task is rather sophisticated hence adult listeners were used for the task.

METHODS

The method of the following research may be described in reference to selection of subjects, experimental apparatus, and specific procedures used for recording results.

Subjects

The subjects selected for the research were three adults, two females and one male. They were 21, 22, and 23 years of age, respectively, and were Kansas State University students. Previous tests by standard audiometric procedures indicated the thresholds of each subject was within normal limits.

Apparatus

The pure tone signals for this experiment were generated by a Hewett Packard 200 car oscillator. The output of the oscillator was fed through an attenuator (Hewett Packard, 350 D) to a recording attenuator (Grason-Stadler, E 362 A). The output of the recording attenuator was fed through a ten ohm resistive mixer to the subject's left earphone (TDH 39). The noise source used was a Grason-Stadler, 901 B noise generator. The output of the noise source was fed through the resistive mixer to the subject's left earphone. The earphone and the subject's control switch for the recording attenvator were located in an Industrial Acoustics Company sound treated booth (Model 1202). The other apparatus was located outside and immediately adjacent to the booth. The pure tone signals at .125k, .25k, .5k, 1k, 2k, 4k, and 8k Hz, were calibrated so that a reading of 60 dB of attenuation on the recording attenvator was equal to zero dB ISO. This calibration was accomplished through the earphone using a Bruel and Kjaer calibration unit (Microphone Amplifier, 2603; Band Pass Filter,1615; and Artificial Ear, 4152).

Procedures

The procedural sequence of Experiment I is listed in Table 1. To determine the threshold levels specified in step 1, the subject was placed in a sound proof booth and earphone were placed on his head. The subject was then instructed to depress the response button when the tone was audible and release it when the tone became inaudible. This provided a continuous tracing of the points of audibility and inaudibility threshold using the Bekesy recorder. After the instructions weare given, the continuous tone was presented through the left earphone and the quiet threshold was determined. When the threshold appeared to be stabilized, white noise was introduced gradually until a 10 dB shift from the quiet threshold occured. This value was recorded as 10 dB effective masking level for S_1. The noise level was then increased until a 20 dB shift from quiet threshold occured. This value was

TABLE 1
Sequence of test prodedures
for Experiment I

Sequence of Experimental Procedures	Description of Experimental Procedures
Step 1	Determine quiet thresholds, 10 dB effective masking levels and 20 dB effective masking levels at each test frequency.
Step 2	After these levels were established, 1K Hz was tested in the following manner: A. Stabilize quiet threshold B. Consume M & M's C. Stabilize quiet threshold D. Consume M & M's E. Stabilize quiet threshold
Step 3	Step 2 repeated, substituting cereal for the M & M's
Step 4	Step 2 repeated, substituting bubble gum for the M & M's
Step 5	In the presence of 10 dB effective masking repeat steps 2, 3, and 4.
Step 6	In the presence of 20 dB effective masking repeat steps 2, 3, and 4.
Step 7	Repeat steps 2 through 6 for .125K, .25K, .5K, 2K, 4K, and 8K Hz.

recorded as 20 dB effective masking level for S_1. This procedure was repeated for each of the frequencies, alternating the three subjects at each frequency presentation. Three trials per subject at each frequency were determined in this manner, and mean quiet thresholds, 10 dB, and 20dB effective masking levels were obtained for each subject. After these levels were determined, step 2 was initiated.

In step 2, a continuous 1K Hz tone was presented through the left earphone to S_1 and his quiet threshold was allowed to stabilize. A signal was then given to the subject to consume 1.7 cubic inches of M & M's. While chewing the M & M's the subject continued to depress and release the response button during periods of audibility and inaudibility respectively. When the M & M's were consumed, the subject's quiet threshold was allowed to restabilize. Upon restabilization, the subject was again signalled to consume 1.7 cubic inches of M & M's. This second tracing through the chewing process was done for reliability purposes. The quiet threshold was again allowed to restabilize.

S_2 and S_3 were then put through the same procedures and when this was completed, step 3 was initiated. It consisted of following the same procedures utilized in step 2, but 1.7 cubic inches of cereal was substituted for the M & M's. The M & M's and cereal are frequently used for reinforcers in the operant hearing testing procedures. Step 4 utilized the same procedures as in step 2, but 1.54 cu. in. of bubble gum was substituted for the M & M's to assess the effects of chewing a physically different substance. At each step, the three subjects were alternated.

Step 5 was a repeat of steps 2, 3 and 4, however, instead of allowing the subject's quiet threshold to stabilize, 10 dB effective masking was presented to the subject's ear throughout this step. Procedures utilizing consumption of M & M's cereal, and gum were otherwise identical to those used above.

Step 6 was identical to step 5 with the exception that 20 dB effective masking was used instead of 10dB effective masking.

After results were obtained for 1K, the other frequencies of 2K, 4K, 8K, .5K, .25K Hz were tested following the same procedures. A total of 315 threshold estimates were obtained for each of the three subjects.

RESULTS

The results for the research for experiment I are presented in reference to the amount of threshold shift for each subject and the subsequent averages, duration of the threshold shifts, and reliability of threshold estimates.

Amount of Threshold Shift

Figure 1 shows a sample of the raw data collected showing the Bekesy tracings for a typical individual subject. The graph shows the threshold tracings of Subject 2 at 1K Hz. The threshold tracing obtained in the quiet condition is denoted by $\overset{1a}{\downarrow}$. In the first tracing, a comparison of this threshold with that obtained when chewing M & M's ($\overset{2}{\downarrow}$) can be seen. The subsequent tracings which immediately follow are the retest data which were done for reliability purposes. The second set of tracings again begins with the quiet threshold ($\overset{1b}{\downarrow}$) and is followed by the threshold tracing obtained when the subject was consuming cereal ($\overset{3}{\downarrow}$). The reliability data again follows, which shows the subject's quiet threshold, threshold when consuming cereal for the second trial and the final quiet threshold. In the third tracing, the quiet threshold ($\overset{1c}{\downarrow}$) is compared with the threshold determined when the subject was chewing gum ($\overset{4}{\downarrow}$). The reliability data follows as in the previous tracings. The threshold estimates were extrapolated by visually fitting a line through

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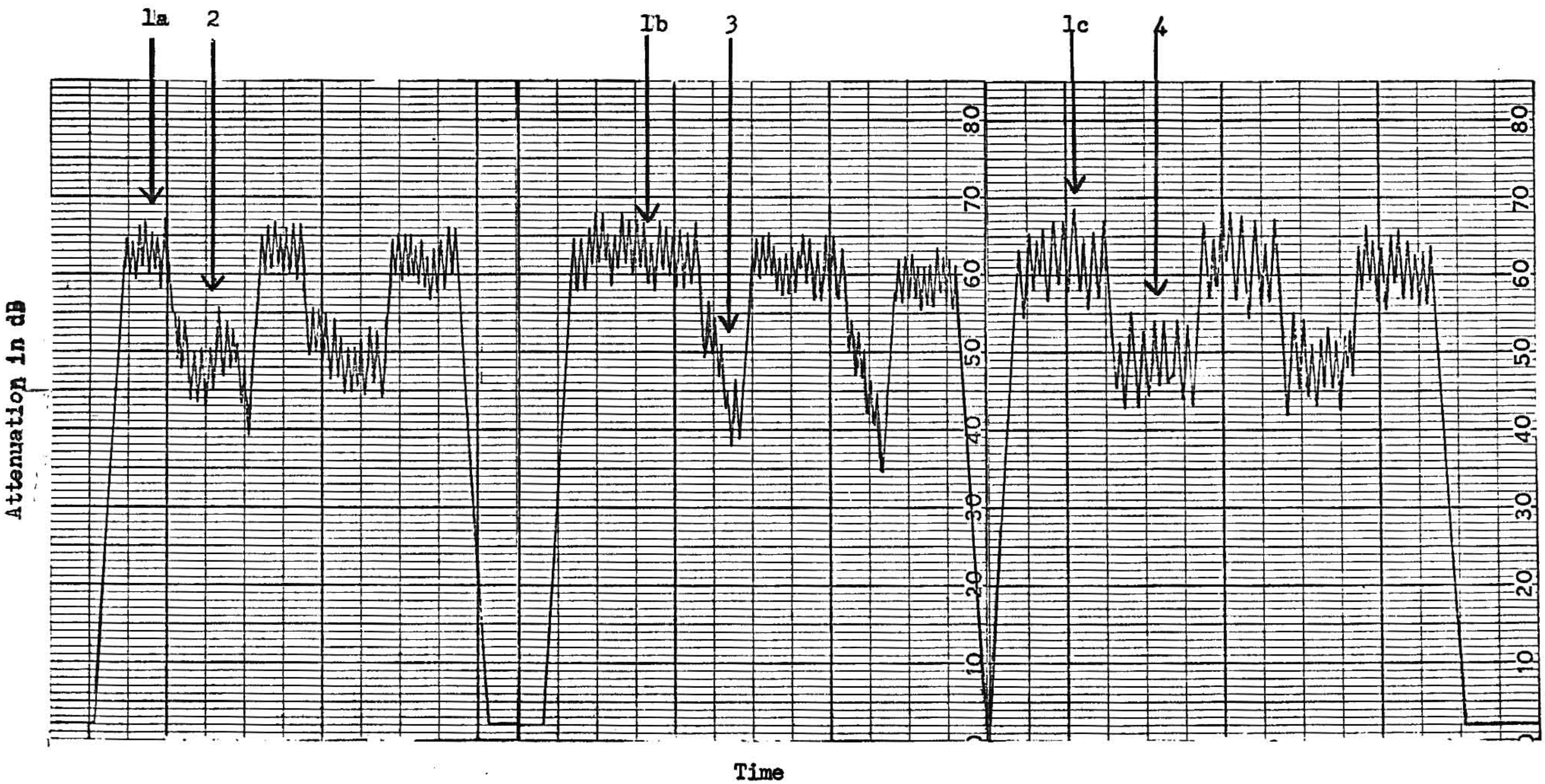


1 → 2: Threshold in Quiet → Threshold when chewing M & M's

3 → 4: Threshold when chewing Cereal → Threshold when chewing Gum

Figure 1. Sample of raw data for Subject 2 illustrating Békésy tracings of Threshold estimates at 1000 Hz.

the average of the maximum and minimum peaks of the tracing during each condition. For example, in the first tracing, the quiet threshold was estimated to be at 63 dB and the threshold when chewing M & M's was estimated to be at 49 dB showing a shift of -14 dB.

To adequately present the individual threshold data that were obtained during this experiment, figures have been drawn for each subject. The figures indicate the amount of shift from thresholds taken in quiet; with 10 dB effective masking, and 20 dB masking during the consumption of M & M's, cereal, and gum, respectively. (Figures 2, 3, and 4).

Each figure, which includes nine graphs, presents the results for one subject. Vertically, the graphs are assembled in the following order: Row 1, chewing effects of all substances in quiet, Row 2 chewing effects of all substances in 20 dB EML. Horizontally, Column 1, effects of chewing M & M's, Column 2, effects of chewing cereal, and Column 3, effects of chewing gum.

Throughout the experiment, Subject 1 (Figure 2) shows the greatest amount of shift during the consumption of M & M's. This threshold shift ranges from -32 dB at .5K Hz to -8 dB at 4K and 8K Hz in the quiet. The amount of shift progressively decreases as the 10 dB and 20 dB effective masking levels were presented. During the presence of 10 dB effective masking level the range was from -18 dB at .25 and .5K Hz to -1 dB at 4K Hz. In the presence of 20 dB EML, the range was from -9 dB at .5K Hz to +7 dB at 8K Hz. The shifts produced by cereal consumption were not quite as high. In the quiet the range was from -30 dB at .5K Hz to -2 dB at 8K Hz; in 10 dB EML the range was from -20 dB at .25K and .5K Hz to -2 dB at 8K Hz; and in 20 dB EML the range was from -12 dB at .25K Hz to

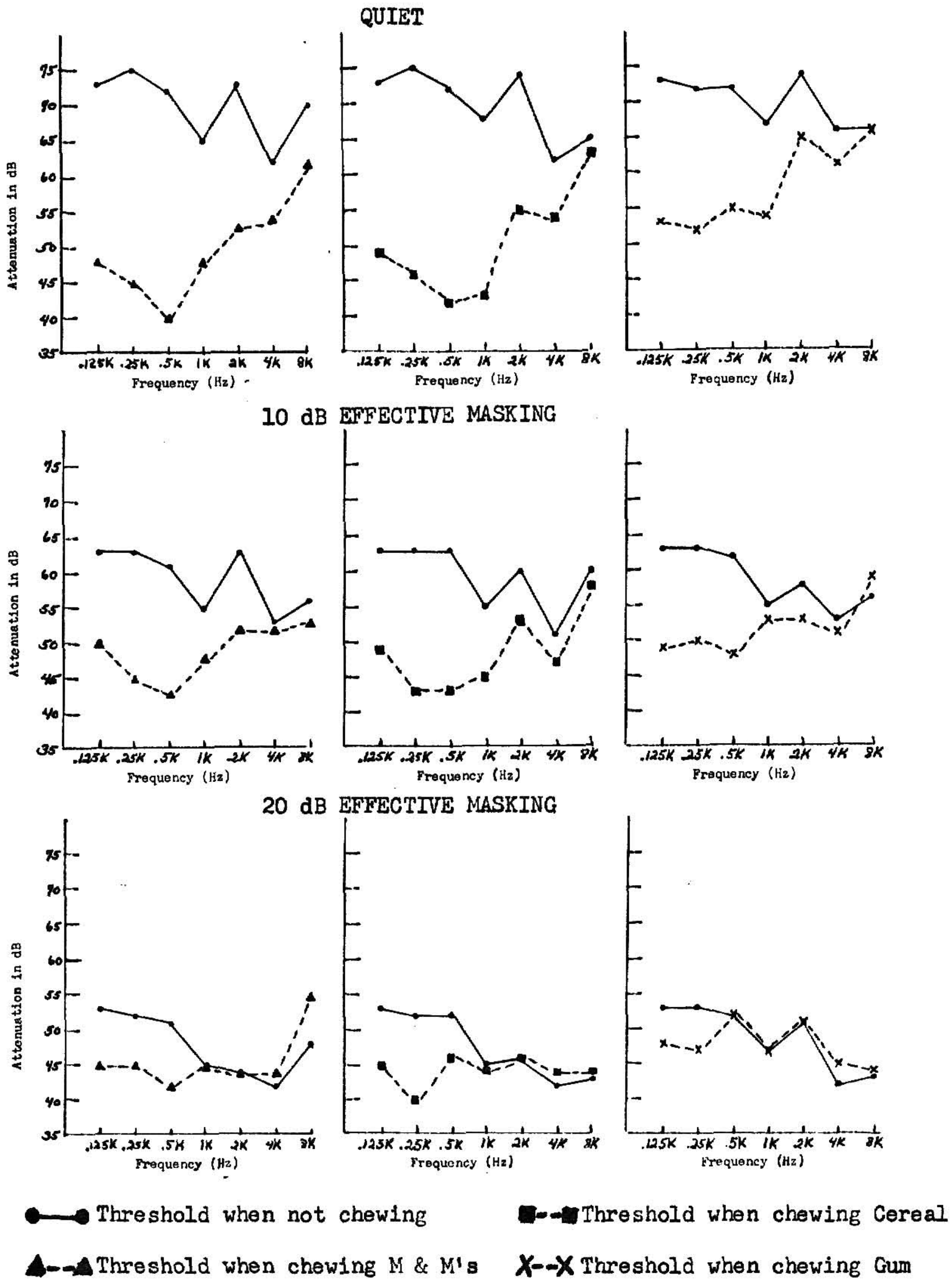
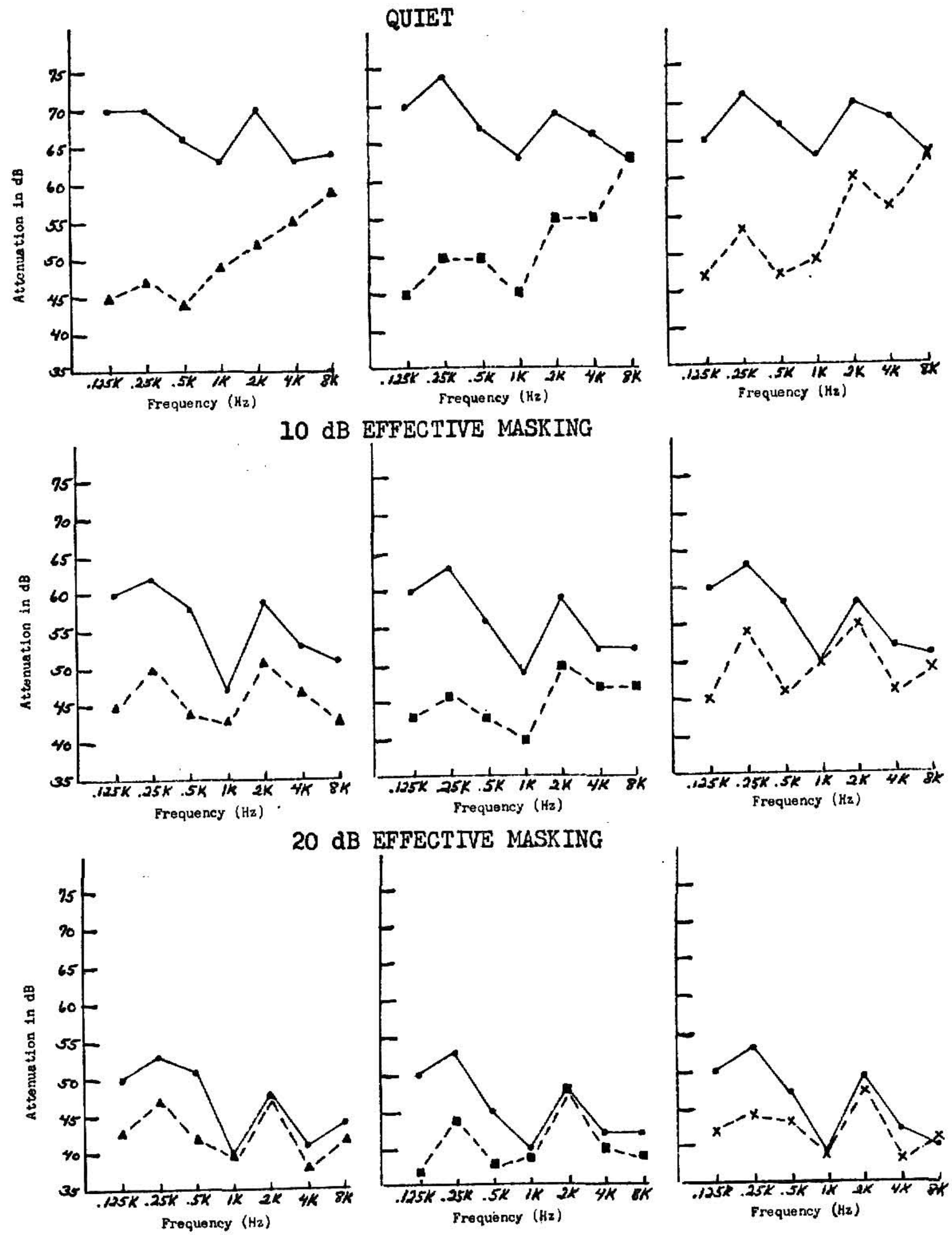


Figure 2. Threshold estimates for Subject 1 in quiet, 10 dB effective masking, and 20 dB effective masking.

+2 dB at 4K Hz. During the chewing of gum, shifts were less substantial, but were clearly observed. In quiet the range was from -12 dB at .125K Hz to +5 dB at 4K Hz; in 10 dB EML shifts ranged from -8 dB at .125K and .25K Hz to -1 dB at 2K and 4K Hz; and in 20 dB EML the range was from -10 dB at .125K Hz to +3 dB at 8K Hz.

Subject 2 (Figure 3) showed similiar shifts during consumption. When chewing M & M's, a shift ranging from -25 dB at .125K Hz to -5 dB at 8K Hz occurred in the quiet. In the presence of 10 dB EML, this range was from -15 dB at .125K Hz to -6 dB at 4K Hz and in 20 dB EML it was from -9 dB at .5K Hz to 0 dB at 1K and 2K Hz. For cereal consumption the effects were as follows: in quiet from -25 dB at .125K Hz to 0 dB at 8K Hz; in 10 dB EML from -17 dB at .125 and .25K Hz to -5 dB at 4K and 8K Hz; and in 20 dB EML from -13 dB at .125K Hz to 0 dB at 2K Hz. During gum chewing, the results showed the following shifts: in quiet, -20 dB at .5K Hz to 0 dB at 8K Hz; in 10 dB EML, -15 dB at .125K Hz to 0 dB at 1K Hz; and in 20 dB EML, -8 dB .125K and .25K Hz to +1 dB at 8K Hz.

Subject 3 (Figure 4) showed less amount of threshold shift, but as is indicated in the figure, his threshold levels while not consuming were consistently higher than those for Subjects 1 and 2. The greatest shift was apparent as with the two previous subjects during the comsumption of M & M's. In quiet the shift ranged from -18 dB at 1K Hz to -8 dB at 4K Hz; in 10 dB EML it was from -15 dB at .125K Hz to +2 dB at 4K Hz; and in 20 dB EML it was from -12 dB at .125K to 0 dB at 4K Hz. The effects for cereal consumption were similar; in quiet -14 dB at .25K Hz to -2 dB at 4K Hz; in 10 dB EML -11 dB at .125K Hz to -3 dB at 4K and 8K Hz, and in 20 dB EML -10 dB at .125K Hz to 0 dB at 2K and 4K Hz. During gum chewing, Threshold shifts were as follows: in quiet from -12 dB at .125K Hz to +5 dB



●—● Threshold when not chewing

■- -■ Threshold when chewing Cereal

▲- -▲ Threshold when chewing M & M's

X- -X Threshold when chewing Gum

Figure 3. Threshold estimates for Subject 2 in quiet, 10 dB effective masking, and 20 dB effective masking.

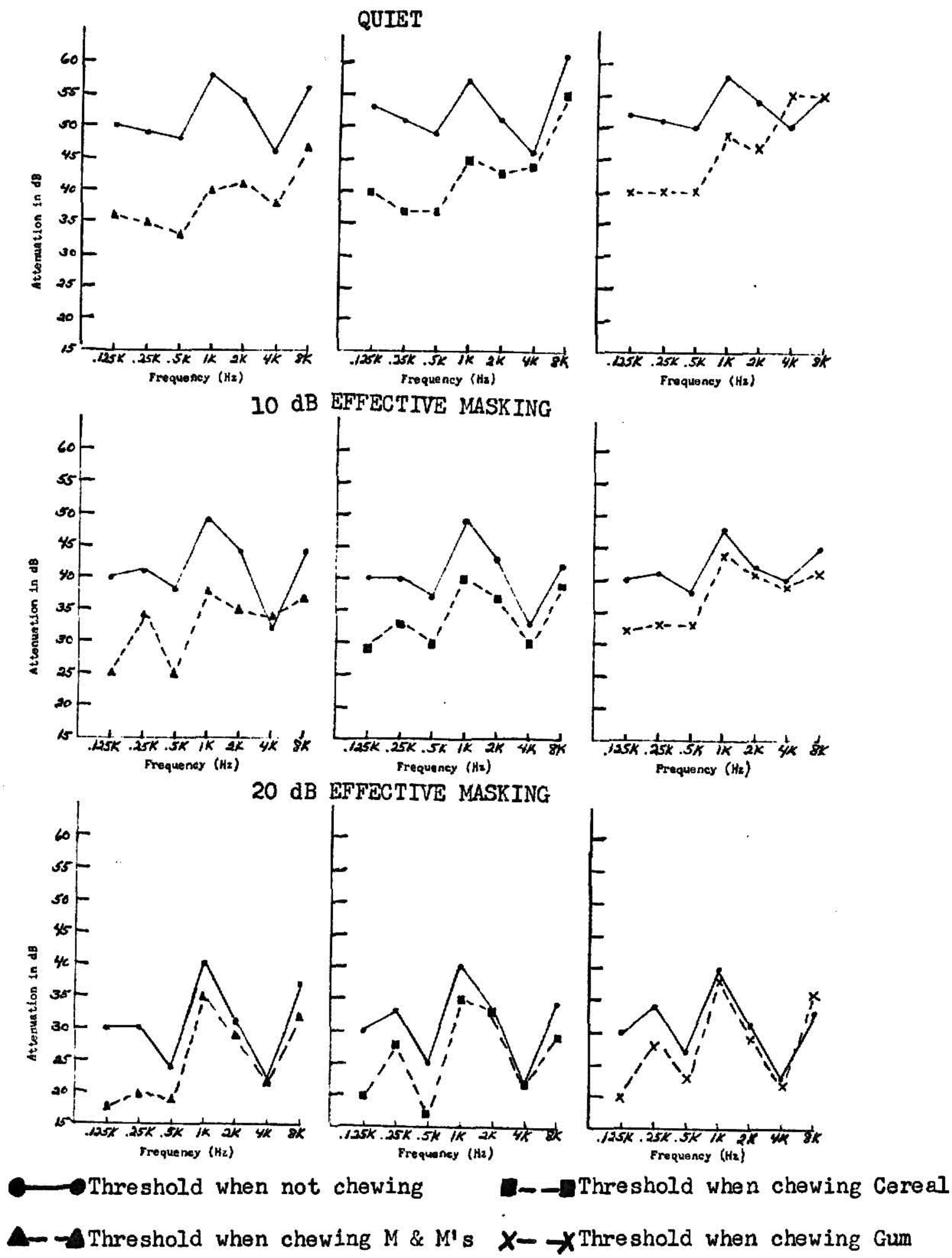


Figure 4. Threshold estimates for Subject 3 in quiet, 10 dB effective masking, and 20 dB effective masking.

at 4K Hz; in 10 dB EML, -8 dB at .125 and .25K Hz to -1 dB at 2K and 4K Hz; and in 20 dB EML, from -10 dB at .125K to +3 dB at 8K.

Tables II, III, and IV show the mean amounts of threshold shift when the data obtained from Subjects 1, 2, and 3 were combined. Table II shows the mean amount of threshold shift resulting from the consumption of each of the three substances, M & M's, cereal, and gum. These results indicate that the greatest amount of shift occurred during the consumption of M & M's at .25K Hz, this value being -24 dB. The least amount of shift occurred at 8K Hz during gum chewing as no shift was indicated on the average. For each substance, the mean shifts were as follows: for consumption of M & M's the range was from -24 dB at .25K Hz to -7.3 dB at 8K Hz; for consumption of cereal, it was from -22.3 dB at .25K Hz to -3 dB at 8K Hz; and during gum chewing it was from -16.6 dB at .125K Hz to 0 dB at 8K Hz.

Table III indicates mean results obtained in the presence of 10 dB EML. The greatest shift was -15 dB at .5K Hz during M & M consumption and the least shift was -1 dB at 8K Hz during gum chewing. The mean range for each substance was from -15 dB at .5K Hz to -1.6 dB at 4K Hz for M & M consumption; from -14.6 dB at .25K Hz to -3.3 dB at 8K Hz for cereal consumption and from -12.4 dB at .125K Hz to -1 dB at 8K Hz during gum chewing.

Mean threshold shifts during the presence of 20 dB EML are indicated in Table IV. The greatest shift here was -10.3 dB at .125K Hz during cereal consumption and the least was 0.0 at 2K & 4K - cereal & 8K M & M. Results for each substance were: M & M consumption ranged from -9 dB at .125K Hz to 0 dB at 8K Hz; cereal consumption from -10.3 dB at .125K Hz to 0 dB at 2K and 4K Hz; and during gum chewing, from -7.6dB at .125K Hz to +1.6 dB at 8K Hz.

Duration of Threshold Shifts

The duration of the threshold shifts varied, depending upon the substances being consumed. However, on the average, the effect induced by M & M consumption was almost twice as long as that induced by cereal consumption. During the consumption of M & M's 49 percent of the threshold shifts lasted for approximately 30.0 seconds and 98 percent ranged from 30.0 seconds to 45.0 seconds in length. The shortest duration during this condition was for a period of 22.5 seconds and the longest was for 45.0 seconds.

The duration of cereal consumption were not as lengthy. This condition produced a threshold shift with durations ranging from 11.2 seconds to 22.5 seconds with 50 percent of the shifts occuring for approximately 15.0 seconds and 93 percent occuring between 15.0 seconds and 22.5 seconds.

Since the mass of gum does not decrease as it is chewed, a period of 30.0 seconds was established as an arbitrary duration rate. It was felt that this provided a sufficient amount of time to study the chewing effects on the subject's threshold.

Tables V, VI, and VII show the mean duration of the threshold shifts at each frequency during each condition. The longest duration of the threshold shifts in quiet was on the average 38.7 seconds during M & M consumption and the shortest was at an average of 15.0 seconds during cereal consumption. This was the same mean range that occured in the presence of 10 dB EML. These values raised somewhat in the presence of 20 dB EML. The longest threshold shift during M & M consumption lasted 39.1 seconds and the shortest duration during cereal consumption was 17.5 seconds.

TABLE II

Mean Threshold Shifts in Quiet

Frequency	M & M's	Cereal	Gum
.125 K Hz	-21.3 dB	-20.6 dB	-16.6 dB
.25 K Hz	-24.0	-22.3	-16.3
.5 K Hz	-23.0	-19.6	-15.6
1 K Hz	-16.3	-15.0	-12.0
2 K Hz	-17.0	-12.0	- 8.6
4 K Hz	- 8.0	- 7.0	- 7.3
8 K Hz	- 7.3	- 3.0	0.0

TABLE III

Mean Threshold Shifts in 10 dB EML

Frequency	M & M's	Cereal	Gum
.125 K Hz	-14.3 dB	-14.0 dB	-12.4 dB
.25 K Hz	-12.3	-14.6	-10.0
.5 K Hz	-15.0	-13.3	-11.0
1 K Hz	- 7.3	- 9.3	- 2.0
2 K Hz	- 9.0	- 7.3	- 3.0
4 K Hz	- 1.6	- 4.0	- 3.0
8 K Hz	- 6.0	- 3.3	- 1.0

TABLE IV

Mean Threshold Shifts in 20 dB EML

Frequency	M & M's	Cereal	Gum
.125 K Hz	-9.0 dB	-10.3 dB	-7.6 dB
.25 K Hz	-7.6	-8.6	-6.6
.5 K Hz	-8.0	-7.0	-2.6
1 K Hz	-1.6	-2.3	- .6
2 K Hz	- .6	0.0	-1.3
4 K Hz	- .3	0.0	- .6
8 K Hz	0.0	-2.3	+1.6

TABLE V

Mean Duration of Threshold Shifts in Quiet

Frequency	M & M's	Cereal	Gum
.125 K Hz	38.7 seconds	19.1 seconds	30.0 seconds
.25 K Hz	32.5	15.0	30.0
.5 K Hz	35.0	17.5	30.0
1 K Hz	29.1	17.5	30.0
2 K Hz	37.5	17.5	30.0
4 K Hz	32.5	17.5	30.0
8 K Hz	35.0	17.5	30.0

TABLE VI

Mean Duration of Threshold Shifts in 10 dB EML

Frequency	M & M's	Cereal	Gum
.125 K Hz	38.7 seconds	19.1 seconds	30.0 seconds
.25 K Hz	34.9	17.5	30.0
.5 K Hz	37.8	17.5	30.0
1 K Hz	35.0	17.5	30.0
2 K Hz	35.0	17.5	30.0
4 K Hz	31.2	17.5	30.0
8 K Hz	35.0	15.0	30.0

TABLE VII

Mean Duration of Threshold Shifts in 20 dB EML

Frequency	M & M's	Cereal	Gum
.125 K Hz	30.0 seconds	20.0 seconds	30.0 seconds
.25 K Hz	35.0	20.0	30.0
.5 K Hz	39.1	17.5	30.0
1 K Hz	35.0	19.1	30.0
2 K Hz	30.0	17.5	30.0
4 K Hz	32.5	20.0	30.0
8 K Hz	37.5	17.5	30.0

Reliability

Test-retest procedures were done for each threshold estimate, giving a total of 315 retest estimates for each indidual subject. S-1 was within ± 5 dB on 312 of the 315 retest threshold estimates and within ± 10 dB on the remaining 3 out of 315. S-2 was within ± 5 dB on all 315 retest estimates and S-3 was within ± 5 dB on 313 of the 315 retest estimates and was within ± 10 dB on 2 out of 315. These provided a total of 940 of the 945 retest estimates within ± 5 dB and 5 out of 945 within ± 10 dB. The data was cursorily inspected in terms of the substance being consumed or the frequency of the tone being presented and no specific patterns were discernable.

CHAPTER 3

EXPERIMENT II

Experiment II was concerned with determining the effects of several consumitory behaviors (i.e. chewing M & M's and cereal) when using standard operant audiometric procedures (Lacrosse & Bidlake, 1964; Fulton and Spradlin, 1968; Lloyd, Spradlin, & Reid, 1968; Bricker & Bricker, 1969; Nowles, 1971; Volkland, 1972). The purpose of this experiment was to determine whether substances which are typically used as reinforcers would affect threshold shifts similar to those yielded in Experiment I. Since operant audiometric procedures are utilized when testing the difficult-to-test population which includes young children, the subjects for this experiment were children from 3 to 5 years old.

METHODS

The method of the following research may be described in reference to selection of subjects, experimental apparatus, and specific procedures utilized in obtaining the results.

Subjects

The subjects for this research were nine normal children ranging from 3 to 5 years with a mean of 4 years. The distribution was as follows: 3-three year olds, 3-four year olds, and 3-five year olds. Six subjects were female and three subjects were male. Seven subjects were volunteers obtained from the student housing area at Kansas State University and two were the children of a faculty member.

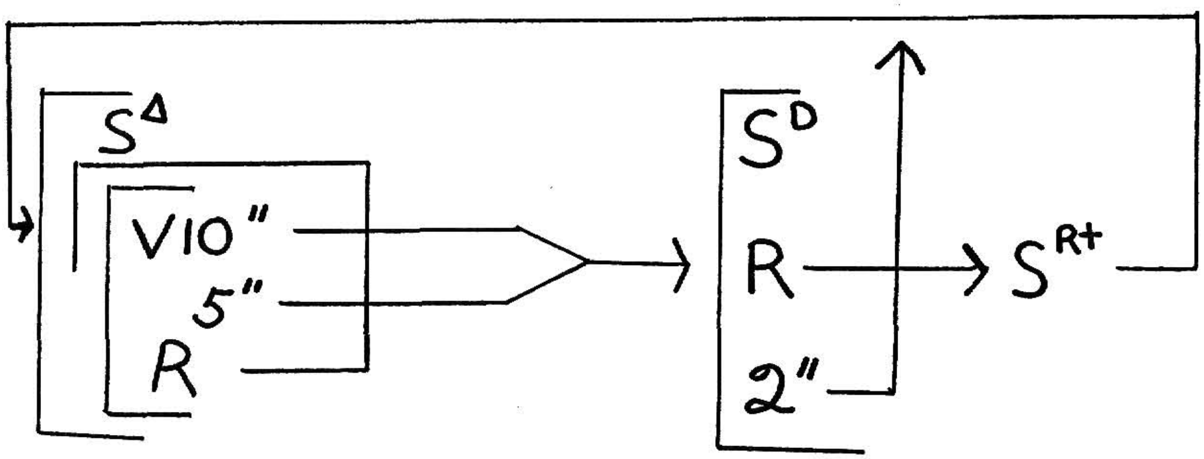
Apparatus

A Maico Model MA-8A audiometer generated and controlled the pure tone stimuli (.125K, .25K, .5K, 2K, 1K, 4K, 8K Hz). The stimuli were presented through TDH-39 earphones. Stimulus levels were calibrated using a Bruel and Kjaer artificial ear, type 4152, a Bruel and Kjaer type 4144 condenser microphone and Bruel and Kjaer, type 2615 pre-amplifier with a Bruel and Kjaer model 2603 microphone amplifier.

All tests were administered in an Industrial Acoustics Company model 1203 auditory test suite. The response-reinforcement delivery box in the test suite contained a Davis universal feeder, model 310, which was activated by the programming equipment in the control room. Upon delivery of reinforcement, the reinforcement tray was illuminated for approximately one second. The response button, a perforated metal plate activated by the subject's touch, was to the right of the reinforcement tray.

Two experimenters were utilized; Experimenter I remained with the subject in the test suite, while Experimenter II controlled the frequency and intensity of the test stimulus at the audiometer. Stimulus duration, reinforcement delivery and stimulus-response records were controlled and recorded by a relay rack consisting of timers, relays and counters. The schedule controlled by the relay equipment is shown in a Mechner diagram form in Figure 5.

In the threshold determination phase of this study, a pure tone was presented to the subject's earphones at the onset of the S^D condition. A response (R), within the time interval (2 seconds) led to reinforcement (S^{R+}). If no response (R) occurred within the time interval (2 seconds), this produced the recycling of the tone off (S^{Δ}) condition. Lapse of a variable time period (VT) of tone off led to a subsequent presentation of the pure tone (S^D). If a response occurred during the tone off condition, the VI tone off condition was recycled.



R - touch response key

S^D - tone on

S^Δ - tone off

→ - produces

↑ - prevents

S^{R+} - reinforcing stimulus

V - variable time

[conditions listed against brackets go into effect simultaneously

Figure 5. Mechner diagram of the terminal training schedule for operant audiometric procedures used in Experiment II.

Procedure

The procedure consisted of three phases: 1) determining the reinforcer to be used according to the conditional group the individual subject being tested was in; 2) stimulus control training conducted through the left earphone; 3) determining threshold estimates through the left earphone for .125K, .25K, .5K, 1K, 2K, 4K, and 8K Hz by a descending-ascending method in conditions 1, 2, and 3.

Experiment II was conducted under three conditions which utilized the following reinforcements (see Table VIII for a graphic display of conditions): 1) cereal and M & M's to be saved by the subject until testing procedures at each frequency were completed; 2) cereal which was to be consumed immediately after it was delivered and 3) M & M's which also were to be immediately consumed. To determine which reinforcer was to be used at what time, the subjects were randomly divided into three groups. The reinforcer sequence utilized for each experimental group was as follows: Group A- 1) reinforcers to be saved by the subject, 2) M & M's to be consumed immediately by the subject, and 3) cereal to be consumed immediately by the subject; Group B- 1) M & M's, 2) cereal, 3) reinforcers to be saved; Group C- 1) cereal, 2) reinforcers to be saved, 3)M & M's. The prescribed reinforcer for each condition was used throughout the testing of all seven frequencies before initiating the next condition.

The pre-training sequence follows: the selected reinforcer was loaded into the delivery box and the child was seated in front of the reinforcement delivery mechanism. The child was given instructions to press the response button whenever he heard the tone. At this time he was also instructed as to whether he should save or immediately consume the reinforcer.

TABLE VIII
Sequence of procedures for Experiment II

	Group A	Group B	Group C
Step 1	Saving S^{R+}, test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz	Consuming S^{R+},(M & M's), test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz	Consuming S^{R+} (Cereal), test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz
Step 2	Consuming S^{R+} (M & M's), test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz	Consuming S^{R+} (Cereal), test for thresholds at .125, .25,.5, 1, 2, 4, 8K Hz	Saving S^{R+}, test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz
Step 3	Consuming S^{R+} (Cereal), test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz	Saving S^{R+}, test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz	Consuming S^{R+} (M & M's), test for thresholds at .125, .25, .5, 1, 2, 4, 8K Hz

The earphones were then placed on his head and a pulsing tone was presented as the discriminative stimulus through the left earphone. Since all of the subjects were thought to be within normal hearing limits, a 70 dB, 1K Hz tone was used as the discriminative stimulus for training purposes. At the time of the tone presentation, experimenter I would demonstrate the response reinforcement relationship by attracting the child's attention and pressing the response button. By touching the response button the subject could observe experimenter I receiving the reinforcement. All of the subjects learned very rapidly and would respond appropriately and independently following the single demonstration. After three consecutive responses the contingencies became such that a response in the presence of the tone provided a reinforcement and terminated the tone-on condition for the variable interval. The tone-on condition was reinstated if no response occurred during the variable interval of tone-off condition. Any response made during tone-off condition delayed the reinstatement of the tone-off condition delayed the reinstatement of the tone-on condition for five seconds and received no reinforcers.

The signals were presented automatically on a variable interval (VI) schedule controlled by the programming equipment. The tone-on condition provided a two second pulsing tone. Therefore if the child did not respond within two seconds the tone-off condition was reinstated. The tone-off duration was at a variable duration of five to twenty five seconds with a mean length of ten seconds. A further delay was caused by any response made during the tone-off condition.

Training was complete with all subjects after five to ten minutes. The training criteria was complete when the child responded to at least ninety percent of the S^D presentations and less than percent to the tone-off (S^{Δ}) condition.

After training was completed, threshold testing was initiated. The descending-ascending method (Carhart-Jerger) 1959 was utilized. The stimulus was lowered in 10 dB steps until there was no response; then the tone was increased 10 dB and lowered in 5 dB steps until there was no response. This was repeated until a 50 percent or three out of six level was obtained as the threshold estimate. Threshold estimates were obtained from each subject for each reinforcement condition. The order of conditions presented was designated by the group to which they were assigned as discussed earlier.

RESULTS

The results for Experiment II are presented in references to the amount of threshold shift produced in each condition and reliability of threshold estimates.

Amount of Threshold Shift

Table IX presents the data for each subject in terms of the amount of threshold shift which occurred during the consumption of M & M's at each test frequency. The quiet thresholds (listed in column 1 of each frequency) were obtained during the condition when M & M's and cereal were presented as reinforcers and the subjects were instructed to save them until the end of the testing procedures. The amount of shift between these quiet threshold estimated when the M & M's were delivered and immediately consumed are shown in the second column of each frequency presentation. The mean values for these two conditions are presented following Subject 9.

The greatest effect produced when consuming M & M's occurred in the lower frequencies of .125K, .25K, .5, and 1K Hz. The mean values of the shifts produced at these frequencies were 9, 3 dB, 9.3 dB, 10.0 dB,

TABLE IX

The amount of threshold shift for each subject in Experiment II when consuming M & M reinforcers.

	.125 K Hz		.25 K Hz		.5 K Hz		1 K Hz	
	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift
S-1	15 dB	5 dB	15 dB	5 dB	10 dB	10 dB	0 dB	20 dB
S-2	10	10	5	15	5	5	10	5
S-3	5	10	5	15	0	20	5	10
S-4	0	10	0	10	0	10	0	0
S-5	15	5	15	5	20	10	15	5
S-6	10	10	10	5	5	5	0	0
S-7	10	5	10	10	0	15	0	10
S-8	20	0	15	5	10	10	0	15
S-9	0	30	10	15	25	10	10	25
X	9.4 dB	9.3 dB	9.4 dB	9.3 dB	8.3 dB	10.0 dB	4.4 dB	10.0 dB

	2 K Hz		4 K Hz		8 K Hz	
	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift
S-1	15 dB	5 dB	5 dB	-5 dB	20 dB	0 dB
S-2	0	0	0	0	10	0
S-3	10	10	0	0	10	0
S-4	0	0	0	0	0	0
S-5	5	5	0	0	10	0
S-6	0	0	0	0	10	5
S-7	0	5	0	10	10	0
S-8	5	15	0	0	20	-10
S-9	10	25	15	20	30	30
X	5.0 dB	7.2 dB	2.2 dB	2.7 dB	13.3 dB	2.7 dB

and 10.0 dB respectively. There was a mean shift of 2.7 dB at 4K and 8K Hz. The extent of the mean shift, and the number of individual subjects showing a shift, and a tendency to decrease as the frequency increased. S-9 showed a shift at all test frequencies. S-1 and S-7 shifted at six out of the seven frequencies and S-3, S-5, and S-8 shifted at five of the test frequencies when chewing M & M's. S-2 and S-6 showed a shift at four frequencies and S-4 shifted at three frequencies. The likelihood of a shift occurring for each individual subject decreased as a function of an increase in frequency. However, the extent of the shift was not predictable for each subject at a particular frequency. The highest shift of 30.0 dB was noted at .125K and 8K Hz for S-9. A shift of 25.0 dB occurred at 1K and 2K Hz, again for S-9. S-3, S-1 and S-9 showed a shift of 20.0 dB at .5K, 1K and 4K Hz respectively. Out of the total shifts occurring when consuming M & M's 44 percent were at or above 10.0 dB.

Table X presents the data showing the effects produced during the consumption of cereal. The quiet threshold estimates were obtained by the procedures described previously. The amount of threshold shifts produced when the subjects immediately consumed the cereal reinforcers is presented in the second column for each frequency in the manner explained for Table IX.

The mean amount of threshold shift produced this condition was not as great as that produced M & M consumption. However, the greatest shifts again occurred in the low frequencies of .25K, .25K, .5K, and 1K Hz. The mean shifts for these frequencies were 7.2 dB, 9.3 dB, 8.8 dB and 8.3 dB respectively. The effects at 2K, 4K and 8K Hz were somewhat different from those which occurred when consuming M & M's. When immediately consuming cereal, a shift of 2.2 dB occurred at 2K Hz, 6.6 dB at 4K Hz, and 1.6 dB at 8K Hz. This shift at 4K Hz was much greater than that which

TABLE X

The amount of threshold shift for each subject in Experiment II when consuming cereal reinforcers.

	.125 K Hz		.25 K Hz		.5 K Hz		1 K Hz	
	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift
S-1	15dB	0 dB	15 dB	5 dB	10 dB	10 dB	0 dB	15 dB
S-2	10	0	5	5	5	5	10	0
S-3	5	5	5	15	0	20	5	5
S-4	0	5	0	10	0	10	0	0
S-5	15	5	15	5	20	0	15	5
S-6	10	20	10	25	5	15	0	10
S-7	10	10	10	10	0	15	0	15
S-8	20	0	15	5	10	10	0	15
S-9	0	20	10	10	25	5	10	10
X	9.4 dB	7.2 dB	9.4 dB	9.3dB	8.3 dB	8.8 dB	4.4 dB	8.3 dB

	2 K Hz		4 K Hz		8 K Hz	
	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift	Quiet Threshold	Amount of Shift
S-1	15 dB	0 dB	5 dB	-5 dB	20 dB	-10 dB
S-2	0	0	0	0	10	-10
S-3	10	0	0	10	10	0
S-4	0	0	0	0	0	0
S-5	5	0	0	10	10	0
S-6	0	0	0	5	10	5
S-7	0	0	0	10	10	5
S-8	5	10	0	5	20	- 5
S-9	10	5	15	25	30	30
X	5.0 dB	2.2 dB	2.2 dB	6.6 dB	13.3 dB	1.6 dB

occurred at the same frequence when chewing M & M's; whereas the shift at 2K Hz is much smaller in comparison.

A shift at each frequency was noted for S-9 when consuming cereal. S-6, S-7, and S-8 showed a shift at six out of the seven test frequencies and S-1 and S-3 shifted at five frequencies. S-5 shifted at four frequencies and S-4 and S-2 showed a shift at three frequencies. The shift which occurred was not predictable for each subject at any particular frequency. S-9 Showed the greatest shift, 30.0 dB, at 8K Hz. A shift of 25.0 dB was noted at .25K and 4K Hz for S-6 and S-9 respectively. S-6 and S-9 showed a 20.0 dB shift at .125K Hz and S-3 showed a 20.0 dB shift at .5K Hz. When consuming cereal, 40 percent of the shifts which occurred were at or above -10.0 dB.

Reliability

During Experiment II, a retest of each subject's threshold estimate was done at 1K Hz in each condition. All nine subjects met the set criterion of ± 5 dB. Of the 27 reliability checks, 82 percent were identical and 18 percent were within ± 5 dB.

CHAPTER IV

DISCUSSION

Results from this research provides pertinent information concerning the use of edible reinforcers in operant audiometric procedures. On the Bekesy tracings obtained in Experiment I, all subjects showed a significant threshold shift when chewing M & M's, cereal, or gum from the threshold estimated in quiet. The greatest shifts occured when chewing M & M's. Results also indicated that the shifts that occurred were a function of frequency. As the frequency increased, the amount of shift tended to decrease. The shifts resulting from chewing any of the three reinforcers may be attributed to the bone conduction masking effect produced by movement of the jaws. In support of this point of view, threshold estimates were obtained when chewing and not chewing in the presence of 10 dB and 20 dB effective masking (Studebaker, 1964). For each subject, the magnitude of the threshold shift decreased as the amount of masking increased.

Experiment II utilized standard operant audiometric procedures with young, normal hearing children (ages 3-5 years). Results were similar to those of Experiment I. The masking effect caused by the consumption of M & M's and cereal was observed as in the previous experiment. The greatest shifts occurred when the child consumed the M & M reinforcer immediately after it was delivered. The effect was most pronounced in the lower frequencies of .125K, .25K, .5K, and 1K Hz. The mean shift which occurred at these frequencies during reinforcer consumption was approximately 10 dB, but did range as high as 30 dB. Several subjects had a quiet threshold estimate of 0 dB and showed no shift when consuming either M & M's or cereal. However, this does not necessarily mean a shift did not occur. The subject's quiet threshold could, in fact, have been below 0 dB and shifted to 0 dB when chewing. Both thresholds would have been recorded as 0 dB since this was as low as the audiometer used was able to test.

The literature concerned with operant audiometric procedures has not been clear with regard to the consumption of the reinforcer and the possible effects involved. Several studies have referred to having the child save the reinforcer (Meyerson and Michael, 1960; Bricker and Bricker, 1969), but there has been no systematic investigation inspecting it further. The usual reason given for encouraging the child to save the reinforcer has been that many children play with the food before or while eating it. The masking effect of the edible reinforcer on the threshold estimates has not been exemplified. The fact that it does occur is clear from the results of the present research.

The typical schedule of tone presentation is a on Variable interval (VI) schedule ranging from 5 to 25 seconds with a mean of 10-15 seconds (Lloyd, Spradlin and Reid, 1968; Volkland, 1972). If the child is allowed to immediately consume the reinforcer when it is delivered and this type of schedule is utilized, the probability of the child chewing during several tone presentations is quite high. This is particularly true if the child tends to hold the food in his mouth several seconds before chewing or if he is a slow chewer. In these cases, the probability of masking out a low frequency tone by chewing would increase. Conversely, fast chewers avoid some of the masking problem. Perhaps factors of these kind would account for the greater variability among subjects in Experiment I as opposed to Experiment II.

Several effects occurred which were not consistent with the expected results. In Experiment I, the threshold estimate became more sensitive when chewing than when not chewing in several cases. For S-1 this occurred at 8K Hz when chewing gum in 10 dB effective masking, at 4K and 8K Hz in 20 dB Effective masking when chewing all three substances. This occurred for S-2 in 20 dB effective masking at 4K and 8K Hz when chewing M & M's and at 8K Hz when chewing gum. S-3 also showed this effect at 4K Hz when chewing gum in the quiet, at 4K Hz when chewing M & M's in 10 dB effective masking, and at 8K Hz in 20 dB effective masking when chewing gum. As can be noted, this occurred only on the higher frequencies and was consistent for all subjects at 8K Hz in 20 dB effecteive masking when chewing gum. However, the difference exhibited were never greater than + 5 dB. In Experiment II, S-9 consistently showed a greater amount of shift, especially at 4K and 8K Hz (-30.0 dB). The reason for such a marked for such a marked shift from the quiet threshold estimate is unknown. However, it was noted that this subject had a tendency to hold the reinforcer in her mouth for several seconds before chewing and also chewed very slowly.

This does not mean that tangible food items should not be utilized as reinforcers. Various alternatives can be inserted within the program to control for effects resulting from immediate consumption of the reinforcer. Reid (1969) investigated varying reinforcement schedules when testing thresholds. A variable interval (VI) schedule of reinforcement was found to be effective. This type of schedule would allow the tester to compare the data obtained when consuming the reinforcer and that which was obtained when no reinforcement was delivered. Another way could be to assess the threshold estimates on an extinction schedule as a type of probe. This could be done at various times throughout the testing procedures, preferably at each frequency to assess what masking may be involved on the reinforced schedule.

Results indicate that when testing by operant audiometric procedures, it is important to consider whether the edible reinforcer was immediately consumed or saved by the child. If the child was consuming the reinforcer, this needs to be taken into account. The tester could very easily over-estimate the amount of hearing loss for the child being tested. The interpretation of the test data would not be realistic. For example, if 15 dB of masking has occurred as a result of consuming the reinforcer, and the child has an air conduction loss of 35 dB, the threshold estimated would be 50 dB. The tester would falsely interpret this as being a more severe loss than in fact, it was. However, if the same amount of masking was occurring and the child had a bone conduction loss of 15 dB or greater, the masking due to reinforcer consumption would not affect the threshold. It would only affect the threshold of a child with an air conduction loss or a child with a bone conductinn loss which was less than the amount resulting from chewing the reinforcer.

If the child will not save the reinforcer, an alternative procedure could be set up which would allow adequate time in the schedule for the reinforcer to be consumed. The audiologist could simply withold further tone presentations until he observes that the edible has been consumed. However, with this type of procedure, testing procedures could become excessively time consuming.

Another possible suggestion has been presented by Bricker and Bricker (1969). It was suggested that the apparatus be altered to despense the reinforcer directly into a covered plastic container or bag until the end of the session. This would allow the child to clearly view the reinforcer without involving the effects of consuming it. However, a system such as this would exclude the child who requires immediate tangible reinforcement in order for the program to be effective.

Further research on the effects of immediate reinforcer consumption is indicated. Retest procedures could be extended to all test frequencies, rather than only 1K Hz. This would be particularly useful at the low frequencies where the phenomenon is more likely to be observed. In the future, research should be conducted with younger normal children (i.e. 2 year olds) and mentally retarded children. These populations are usually tested by operant audiometric procedures which utilize edible reinforcers similar to those used in this research.

Presently, it seems that immediate consumption of edible reinforcers does cause a masking effect. This effect may cause an overestimation of the child's true threshold. Consideration must be given to this factor when interpreting audiometric results utilizing operant procedures.

CHAPTER V

SUMMARY

The purpose of this research was to investigate the effects of reinforcer consumption on threshold estimates. Operant audiometric procedures are used extensively when testing the difficult-to-test population. Edibles such as cereal and M & M's are commonly utilized as reinforcers. It is important to know if immediate reinforcer consumption does in fact mask the tone presentation and cause a shift in threshold estimates. An attempt was made to establish whether there is a significant threshold shift when consuming the reinforcer, and if there is, to determine when it occurs and approximately to what degree it occurs.

In order to assess the effects of reinforcement consumption on threshold estimates, the present research was divided into two experiments. In Experiment I, three normal hearing adults served as subjects. A continuous tone which increased or decreased in intensity as the subject depressed and released the response button was presented through the left earphone. The frequency of the tone was controlled by the experimenter. The test frequencies included .125K, .25K, .5K, 1K, 2K, 4K, and 8K Hz. Each subject's threshold was traced on a recording attenuator.

The procedural sequence for each subject was as follows:

1. Determine quiet thresholds, 10 dB effective masking levels and 20 dB effective masking levels at each test frequency.
2. After these levels were established, each frequency was tested in the following manner:
    A. Stabilize quiet threshold
    B. Consume M & M's
    C. Stabilize quiet threshold
    D. Consume M & M's
    E. Stabilize quiet threshold

3. Step 2 repeated, substituting cereal for the M & M's.

4. Step 2 repeated, substituting bubble gum for the M & M's.

5. In the presence of 10 dB effective masking, repeat steps 2, 3, and 4.

6. In the presence of 20 dB effective masking, repeat steps 2, 3, and 4.

The data from all three subjects showed a significant threshold shift when chewing M & M's, cereal, or gum from the threshold estimated when not chewing. These effects occured as a function of frequency. The magnitude of the threshold shift decreased as the amount of masking increased.

Experiment II utilized standard operant audiometric procedures with normal hearing children with a mean age of 4 years. Automatic programming equipment controlled the stimulus duration, variable time intervals between stimulus presentations and reinforcement delivery. Stimulus intensity and frequency were controlled by the experimenter at the audiometer.

The procedure for Experiment II was as follows:

1. Determine the reinforcer to be used.

2. Stimulus control training through the left earphone.

3. Determine the threshold estimates for .125K, .25K, .5K, 1K, 2K, 4K, and 8K Hz by a descending-ascending method in conditions where the subject was instructed to do one of the following:
    A. Save the reinforcer
    B. Immediately consume the M & M reinforcer
    C. Immediately consume the cereal reinforcer

Threshold shifts attributed to bone conduction masking were observed when the child consumed the reinforcer immediately after it was delivered. As in Experiment I, the threshold shifts occured as a function of frequency. The mean shift which occured was approximately 10dB, but did range as high as 30 dB.

These results indicate that when testing by operant audiometric procedures, it is important to consider whether the edible reinforcer was immediately consumed or saved by the child. It appears that immediate consumption of the reinforcer does cause a threshold shift which may be explained as a masking effect. This effect may cause an overestimation of the child's true threshold estimate. Consideration must be given to this factor when interpreting audiometric results utilizing operant procedures.

Further research on the effects of immediate reinforcer consumption is indicated. This should be conducted with younger normal children (i.e. 2 year olds) and mentally retarded children. These populations are usually tested by operant audiometric procedures which utilize edible reinforcers similar to those used in this research.

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AUDITORY THRESHOLD SHIFTS AS A FUNCTION
OF REINFORCER CONSUMPTION

by

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The purpose of this research was to investigate the effects of reinforcer consumption on threshold estimates. Operant audiometric procedures are used extensively when testing the difficult-to-test population. Edibles such as cereal and M & M's are commonly utilized as reinforcers. It is important to know if immediate reinforcer consumption does in fact mask the tone presentation and cause a shift in threshold estimates. An attempt was made to establish whether there is a significant threshold shift when consuming the reinforcer, and if there is, to determine when it occurs and approximately to what degree it occurs.

In order to assess the effects of reinforcement consumption on threshold estimates, the present research was divided into two experiments. In Experiment I, three normal hearing adults served as subjects. A continuous tone which increased or decreased in intensity as the subject depressed and released the response button was presented through the left earphone. The frequency of the tone was controlled by the experimenter. The test frequencies included .125K, .25K, .5K, 1K, 2K, 4K, and 8K Hz. Each subject's threshold was traced on a recording attenuator.

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   - C. Stablilize quiet threshold
   - D. Consume M & M's
   - E. Stabilize quiet threshold

3. Step 2 repeated, substituting cereal for the M & M's.

4. Step 2 repeated, substituting bubble gum for the M & M's.

5. In the presence of 10 dB effective masking, repeat steps 2, 3, and 4.

6. In the presence of 20 dB effective masking, repeat steps 2, 3, and 4.

The data from all three subjects showed a significant threshold shift when chewing M & M's, cereal, or gum from the threshold estimated when not chewing. These effects occured as a function of frequency. The magnitude of the threshold shift decreased as the amount of masking increased.

Experiment II utilized standard operant audiometric procedures with normal hearing children with a mean age of 4 years. Automatic programming equipment controlled the stimulus duration, variable time intervals between stimulus presentations and reinforcement delivery. Stimulus intensity and frequency were controlled by the experimenter at the audiometer.

The procedure for Experiment II was as follows:

1. Determine the reinforcer to be used.

2. Stimulus control training through the left earphone.

3. Determine the threshold estimates for .25K, .25K, .5K, 1K, 2K, 4K, and 8K Hz by a descending-ascending method in conditions where the subject was instructed to do one of the following:
    A. Save the reinforcer
    B. Immediately consume the M & M reinforcer
    C. Immediately consume the cereal reinforcer

Threshold shifts attributed to bone conduction masking were observed when the child consumed the reinforcer immediately after it was delivered. As in Experiment I, the threshold shifts occured as a function of frequency. The mean shift which occured was approximately 10dB, but did range as high as 30 dB.

These results indicate that when testing by operant audiometric procedures, it is important to consider whether the edible reinforcer was immediately consumed or saved by the child. It appears that immediate consumption of the reinforcer does cause a threshold shift which may be explained as a masking effect. This effect may cause an overestimation of the child's true threshold estimate. Consideration must be given to this factor when interpreting audiometric results utilizing operant procedures.

Further research on the effects of immediate reinforcer consumption is indicated. This should be conducted with younger normal children (i.e. 2 year olds) and mentally retarded children. These populations are usually tested by operant audiometric procedures which utilize edible reinforcers similar to those used in this research.