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US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY 40121

REPORT NO. 751

EFFECTS OF ATTENDING TO AUDITORY SIGNALS ON THE MAGNITUDE OF THE ACOUSTIC REFLEX

(Progress Report)

by

Walter J. Gunn, M.A.

25 September 1967

UNITED STATES ARMY
MEDICAL RESEARCH AND DEVELOPMENT COMMAND

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EFFECTS OF ATTENDING TO AUDITORY SIGNALS ON THE MAGNITUDE OF THE ACOUSTIC REFLEX

(Progress Report)

by

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Experimental Psychology Division
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ABSTRACT

EFFECTS OF ATTENDING TO AUDITORY SIGNALS ON THE MAGNITUDE OF THE ACOUSTIC REFLEX

OBJECTIVE

The objective in the experiments to be described was to measure the effects of attention demanding conditions on the magnitude of the acoustic reflex.

METHOD

In the first experiment, subjects were required to detect faint signals (threshold level clicks) in either the phone ear or probe ear while the acoustic reflex was elicited by a 1 second, 1500 Hz tone. The control condition consisted of merely remaining alert but not listening for a signal during the reflex elicitation. In the second experiment, subjects tracked a 250 Hz threshold level tone before and during eliciting tones of 15 seconds duration in the same ear. In the control condition, they merely remained alert during the elicitation.

SUMMARY

The first experiment did not demonstrate any significant effect of listening for faint clicks in either contralateral or homolateral ear on the magnitude of the acoustic reflex. The second experiment did show the magnitude of the acoustic reflex to be significantly larger when the subjects tracked a 250 Hz tone than when not tracking.

CONCLUSION

The results of the two experiments do not support the hypothesis of Smith and Loeb (1967) that subjects might inhibit the acoustic reflex when listening for faint sounds.

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EFFECTS OF ATTENDING TO AUDITORY SIGNALS ON THE MAGNITUDE OF THE ACOUSTIC REFLEX

INTRODUCTION

In recent years, several investigators have published the results of studies concerned with the effects of various mental tasks on the amount of temporary threshold shift (TTS) incurred by subjects exposed to various levels of acoustic stimulation. These results have not been completely in agreement and many reasons for the discrepancies have been submitted, such as differences in degree or kind of mental tasks performed by subjects during exposure. For instance, Wernick and Tobias (28) found that the temporary threshold shift (TTS) resulting from both low-level and high-level auditory fatigue was increased when, during exposure to the fatiguing stimulus, subjects performed mental arithmetic tasks as opposed to relaxing in reverie states. However, three subsequent reports (1, 20, 27) failed to substantiate the Wernick and Tobias (28) data. In the first two of these reports, different "mental tasks" were employed. The work of Wernick and Tobias (28) was replicated exactly by Capps and Collins (3) since not all tasks appeared to be equally potent in producing a given sensory effect. They confirmed the finding that the mental arithmetic task during the fatigue period resulted in statistically greater TTS than the reverie condition, and suggested that the task employed by Ward and Sweet (27) and those used by Bell and Stern (1) might not have been equivalent to mental arithmetic. Capps and Collins (3) also noted that the large TTS obtained by Riach and Sheposh (20) for the reverie condition under low-level fatigue (about 9 dB) was far out of the range of values (2.3 - 4.1 dB) reported by other investigators for the same condition (1, 3, 28). In a later investigation (4), the same individuals reported significant increases in TTS produced by a 40 dB, 4 KHz tone when subjects were engaged in either mental arithmetic or written long division while no significant influence on TTS was produced by having subjects track a 500 Hz threshold tone.

In another experiment, Fricke (7) exposed subjects to 100, 110, or 120 dB white noise for 15 minutes and in two conditions they either listened for interruptions in the noise or to a story to which they were supposed to attend. Although there was some tendency for noise-plus-story TTS to be greater at 110 dB, generally differences were not significant as a function of the attention demanding condition.

Lehnhardt (13) administered a drug, much like curare (myoerelaxin) and reported that AR action (as measured by an impedance change procedure) was abolished and that exposure to a random noise while under the influence of the drug produced significantly greater low frequency TTS and less high frequency TTS than under control conditions. However, Smith et al (24) found no significant changes in TTS following exposure to high frequency broad band noise while under the influence of d-tubocurarine, although there was a significant increase in TTS produced by low frequency broad band noise. They also found a small, but statistically significant decrease in ipsilateral remote masking after administration of the drug.

The results of Smith et al (24) are in partial agreement with those of Bilger (2) in which one group of subjects who had had their stapedius muscles surgically excised and another group with normal ears were compared in an experiment on remote and contralateral remote masking. The results showed that neither remote nor contralateral remote masking depends upon the stapedial reflex. The disagreement lies in the area of ipsilateral remote masking and it is not understood why d-tubocurarine caused a decrease in ipsilateral remote masking in the experiment by Smith et al (24) while stapedectomized subjects (2) did not differ significantly from normals in this regard.

In an earlier study, Loeb and Riopelle (16) performed two experiments, employing different psychophysical procedures, in which they measured attenuation due to the acoustic reflex at intensities near the threshold. In both experiments, a contralateral tone was introduced to activate a reflex and the resultant threshold shift for a test tone noted. Shifts observed were small and apparently inconsistent with findings of past experiments. The hypothesis was advanced that the reflex, once activated, attenuated loud sounds more than faint ones. Two additional experiments employing a loudness-matching technique were devised as a test of this hypothesis. In both of these, the apparent loudness of different test tones was noted in the presence of a contralateral activating tone. Results were in accord with their prediction, showing that loud sounds apparently are attenuated more than faint ones. It was suggested that inhibitory control over the AR by subjects attempting to better hear faint sounds may be a possible explanation of these findings.

Smith and Loeb (25) performed a series of four experiments in which they measured TTS produced by longer exposures to fairly intense stimuli under different activating or attention demanding conditions. In the first of these experiments, subjects were exposed to a 100 dB, 1 KHz tone for 10 minutes while either performing mental arithmetic tasks (MA) similar to the ones used by Wernick and Tobias

(28) or engaged in reverie (REV). Results showed no significant difference between the TTS produced by the two conditions. In the second experiment, subjects were exposed for 15 minutes to a 100 dB, 1 KHz tone and told to employ a pencil and paper in the MA task. Again, there was no significant difference between the MA and REV TTS. In the third experiment, subjects were exposed to a 90 dB tone and a 100 dB tone in different sessions while either tracking or not tracking their thresholds for a 1 KHz tone in the opposite ear. Surprisingly, they found that there was significantly greater TTS under the tracking conditions. Because the results were significant only beyond the .05 level, a replication of the third condition was carried out. Again, the TTS was greater when subjects were exposed while tracking than when exposed during reverie, and this difference was highly significant ($p < .01$). To test the effect of arousal (a possible explanation for the above results), a fourth experiment was performed in which d-amphetamine was given to increase arousal level and seconal was given to decrease arousal level. Subjects were exposed to a 90 dB, 1 KHz tone for 15 minutes in d-amphetamine, seconal, or placebo conditions. Variance between drug conditions did not attain statistical significance. Since the drug experiment suggests that any effects are not due to general level of arousal, Smith and Loeb suggest that possible inhibition of the acoustic reflex (AR) may take place when observers are trying to detect a threshold level signal. Wernick and Tobias (28) ruled out the AR in their experiments because they felt that it would be ineffective for the frequencies and levels which they employed. Although this is debatable, it would not apply to the intensities and frequencies employed in the Smith and Loeb (25) experiments.

In order to test the notion of inhibition of the AR while listening for faint signals or tracking a threshold level tone, two experiments were conducted in which the main objective was to measure the effects of attention demanding conditions on the magnitude of the AR. In the first of these, subjects were required to detect faint signals in either phone or probe ear while the acoustic reflex was being elicited. The control condition consisted of just remaining alert but not listening for a signal, during the reflex elicitation. In the second experiment, subjects tracked a 250 Hz threshold before and during eliciting tones and in the other condition merely remained alert during the elicitation.

EXPERIMENT I

Procedure.

Subjects. Fifteen volunteer male subjects 18 to 22 years of age, assigned to the US Army Medical Research Laboratory at Fort Knox, were screened for obvious auditory defects prior to participation in this experiment. Subjects having a hearing loss greater than 20 dB in the frequency range of 250 to 8000 Hz were not permitted to participate in the experiment.

Method. Each subject served in all three conditions in each of three sessions which were given on three different days. Conditions were counterbalanced in an attempt to minimize temporal or order effects. Subjects were fitted with an earphone (Telephonics, Type TDH-39) over one ear for the eliciting stimulus and a probe in the other ear for measuring the acoustic impedance of the ear. The probe sends a 220 Hz tone into the ear, which is reflected by the tympanic membrane and picked up by a tiny microphone which is also in the probe. The output of the microphone is compared with a reference signal and a null is obtained on the meter by adjusting the amplitude and phase of the reference. Any change in acoustic impedance of the ear (for example, due to contraction of the middle ear muscles) causes an unbalance of the nulling meter. (See Appendix A for a more complete description of the Madsen Acoustic Impedance Meter, Type Z 061.) In condition 1, subjects were instructed not to expect a signal during the 1-second acoustic reflex eliciting tone of 1500 Hz. The intensity of the eliciting tone was adjusted to a level which caused a 50 to 80 percent of full scale reading on the nulling meter of the Madsen Acoustic Impedance Meter. Ten reflexes were accumulated on a computer of average transients (TMC, Type CAT 1000) and a magnitude versus time plot was made on an X-Y recorder (Houston Instruments, Type HR-97). In condition 2, subjects were instructed to listen for and count (mentally) a number of threshold level signals occurring in the phone ear during the 1-second eliciting tone. The signal consisted of a faint click superimposed on the eliciting tone, and was adjusted individually for each subject to obtain a threshold level by the method of limits, prior to the measured reflexes. Signals occurred during all eliciting tones except the ones (as determined by a random schedule) during which the reflex was measured and accumulated. In this way, it was possible to measure the magnitude of the reflex in response to an eliciting tone identical with that employed in condition 1, the only difference being the attention of the subject to the phone. Ten reflexes were measured, accumulated, and plotted against time. The subject then reported the number of signals he detected. In condition 3, subjects were instructed to listen for a signal (a brief threshold-level click) in the probe ear during the 1-second eliciting tone and to report at the end of the run the number counted. Signals occurred during all eliciting tones except the ones (as determined by a random schedule) during which the reflex was measured and accumulated. In this way, it was possible to measure the magnitude of the reflex in response to an eliciting tone identical with that employed in condition 1, the only difference being the attention of the subject to the probe. Ten reflexes were measured, accumulated, and plotted against time. The subject then reported the number of signals he had detected. In conditions 2 and 3, one out of five eliciting tones contained no signal, as determined by a random schedule.

Apparatus. In Experiment I, an Acoustic Impedance Meter (Madsen, Type Z 061) was used to indicate changes in the acoustic impedance of the ear in which the probe is inserted. The meter also has a calibrated output to an earphone (Type TDH-39) which provides the AR eliciting tone to the contralateral ear. Another A-C output of the meter, proportional to the acoustic impedance of the ear being measured, is rectified by a wave analyzer (General Radio Type 1900-A) and accumulated on a computer of average transients (TMC, Type CAT 1000). The contents of the CAT are plotted against time on an X-Y plotter (Houston Instruments, Type HR-97). Presentation of stimuli was controlled by a digital programming system. A system diagram and detailed description of operation of the complete system is given in Appendix A, while a detailed description of the acoustic impedance meter is given in Appendix B.

Results. Table 1 shows mean area for each combination of condition and session.

TABLE 1

Mean Areas as a Function of Condition and Session

Session	Condition		
	No Signal	Phone Signal	Probe Signal
I	112.4	99.3	108.6
II	128.1	130.3	125.0
III	158.9	118.6	126.7

The summary of the analysis of variance for areas (AxBxS, Lindquist, 1953) is given in Table 2, and shows no significant difference between conditions (listening for signal in phone, in probe, or no signal) or between sessions and no significant interaction.

TABLE 2

Summary of Analysis of Variance for Areas, Experiment I

Source of Variance		d.f.	Mean Squares	F
A	Conditions: phone, probe and no signal	2	3,592	2.195
B	Sessions	2	9,558	0.150
S	Subjects	14	15,119	
	AB	4	2,017	0.073
	AS	28	1,636	
	BS	28	63,781	
	ABS	56	27,647	
	TOTAL	134		

Table 3 shows mean maximum amplitude for each combination of condition and session.

TABLE 3

Mean Maximum Amplitudes as a Function of Condition and Session

Session	Condition		
	No Signal	Phone Signal	Probe Signal
I	7.6	6.9	7.5
II	10.7	10.3	10.2
III	11.9	9.7	9.9

The summary of the analysis of variance for maximum amplitude is given in Table 4, and like the analysis of variance for areas, shows no significant effect for condition or significant interactions. However, there is a significant increase ($p < .05$) in amplitude with sessions.

TABLE 4

Summary of Analysis of Variance for Maximum Amplitude, Experiment I

Source of Variance		d.f.	Mean Squares	F
A	Conditions: phone probe and no signal	2	15,734	1.828
B	Sessions	2	146.431	4.513*
S	Subjects	14	55.961	
	AB	4	5.247	0.566
	AS	28	8.608	
	BS	28	32.443	
	ABS	56	9.268	
	TOTAL	134		

*($p < .05$)

Discussion. The results of Experiment I fail to support the notion of inhibition of the acoustic reflex by a subject attending to a faint click, either in the contralateral or ipsilateral ear. The significant difference between sessions may possibly be attributable to familiarity with the test situation. It was noted that subjects in the test situation for the first time were more nervous and active than experienced ones. It was therefore more difficult to maintain a stable null reading on the acoustic impedance meter, since swallowing, head and face movement, and heart beat all caused instability of the basal level of acoustic impedance. The output of the acoustic impedance meter is reduced somewhat if the meter is not properly nulled. As the subject gains confidence and familiarity with the situation, he becomes less restless and it is easier to keep the meter properly nulled in order to obtain a maximum output for a given reflex action. The failure to obtain a significant difference between conditions may be due to either non-existence of any real difference, or insufficient duration of attention demanding signal relative to the overall duration of the eliciting tone. It seemed possible that an effect, if it existed, might better be detected if the attention span required were longer than that required for detecting a click in a 1-second eliciting tone. The second experiment therefore was designed to increase the length of the attention demanding task and thereby increase the relative difference in the magnitude of the AR, if any, in the attentive and inattentive conditions.

EXPERIMENT II

Procedure.

Subjects. Fifteen volunteer subjects assigned to the US Army Medical Research Laboratory at Fort Knox were screened for obvious auditory defects prior to participation in this experiment. Although the criterion for rejection was the same as in Experiment I, different subjects participated in Experiment II.

Method. Each subject served in three sets of conditions on three different days. In each set of conditions, the subject would either track a 250 Hz threshold, by the Békésy method, and continue to do so while his acoustic reflex was being elicited by a loud tone of a particular frequency, or not track while having the reflex elicited by that same frequency. A different eliciting tone frequency was used in each of the three sets, namely, 1000, 2000, and 3000 Hz. Tracking and not tracking conditions and frequency of eliciting tone were counterbalanced in order to minimize temporal or order effects. Eliciting ones were 15 seconds in duration and were adjusted for each individual to give a meter deflection of 50 to 80 percent of full scale. Ten reflexes were measured, accumulated, and plotted against time for each subject under each of the six conditions which are summarized below:

	Condition	Eliciting Tone
1.	Not tracking	1000 Hz
2.	Not tracking	2000 Hz
3.	Not tracking	3000 Hz
4.	Tracking	1000 Hz

Condition	Eliciting Tone
5. Tracking	2000 Hz
6. Tracking	3000 Hz

The three sets consisted of conditions 1 and 4, 2 and 5, and 3 and 6.

Apparatus. The apparatus for Experiment II is similar to that employed in Experiment I, with the addition of a recording attenuator (Grason Stadler, Model E3262A) which is used by the subjects while tracking, and an audio frequency oscillator (Hewlett Packard, Model 202D) which was fed into the attenuator. A system diagram and detailed description of operation of the complete system is given in Appendix C.

Results. Table 5 shows mean areas under the magnitude versus time plots for each combination of condition and set (eliciting tone frequency).

TABLE 5

Mean Areas as a Function of Eliciting Tone Frequency and Condition

Frequency (Hz)	1000		2000		3000	
	TR	NTR	TR	NTR	TR	NTR
Mean area	120.2	114.7	128.2	110.9	100.5	98.5

TR indicates the tracking condition
NTR indicates the non-tracking condition

The summary of the analysis of variance is given in Table 6 (next page) and shows a significant difference ($p < .05$) between the tracking and non-tracking conditions, no significant difference between sets, and no significant interaction. Figure 1 (next page) shows mean areas for the tracking and non-tracking conditions plotted against eliciting tone frequency. The effect of tracking appears to be greatest at 2000 Hz, and less at 1000 and 3000 Hz, but the effect of frequency was not significant.

TABLE 6

Summary of Analysis of Variance for Areas, Experiment II

Source of Variance	d.f.	Mean Squares	F
A Conditions	1	1,754	7.69*
B Frequency	2	3,769	1.18
S Subjects	14	12,094	
AB	2	360	0.578
AS	14	228	
BS	28	3,183	
ABS	28	623	
TOTAL	89		

*($p < .05$)

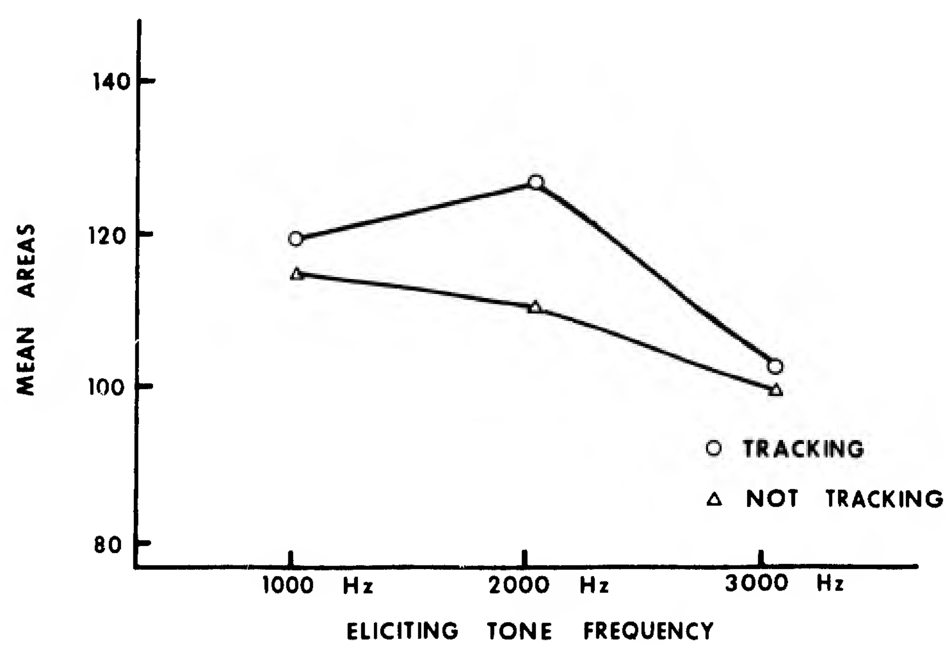

Fig. 1. Mean areas, Experiment II.

Table 7 shows the mean measured maximum amplitudes for each combination of condition and set (eliciting tone frequency).

TABLE 7

Mean Maximum Amplitude as a Function of Eliciting Tone Frequency and Condition

Frequency (Hz)	1000		2000		3000	
	TR	NTR	TR	NTR	TR	NTR
Mean maximum amplitude	5.48	5.27	5.99	5.18	4.99	4.85

TR indicates the tracking condition
NTR indicates the non-tracking condition

The summary of the analysis of variance for maximum amplitudes is given in Table 8 (next page) and shows a significant difference between the tracking and non-tracking conditions, no significant difference between sets, and no significant interaction. Figure 2 (next page) shows mean maximum amplitudes for the tracking and non-tracking conditions plotted against eliciting tone frequency. The largest effect appears to be in the middle frequency region, but, again, the effect of frequency was not significant.

Discussion. The results of Experiment II do not support the notion of inhibition of the AR by subjects listening for faint sounds, and in fact indicate just the opposite effect. The analysis of variance on both area and maximum amplitude of the AR shows the reflex to be significantly larger when the subject tracks his threshold at 250 Hz. From the Smith and Loeb experiments (25), one might predict that since subjects tracking their thresholds experience greater TTS than subjects engaged in reverie, that possibly the AR was not offering as much protection in the tracking condition, if the difference in TTS can be accounted for on the basis of the acoustic reflex. It is difficult to reconcile the results of Experiment II with those of Smith and Loeb (25) unless consideration is given to the possibility of the existence of some central factor, such as that suggested by Wernick and Tobias (28). They suggest that there is a chemical mediator required for initiating the neural response and that efferent stimulation tends to decompose

TABLE 8

Summary of Analysis of Variance for Maximum Amplitude, Experiment II

Source of Variance	d. f.	Mean Squares	F
A Conditions	1	33.64	5.663*
B Frequency	2	34.57	0.291
S Subjects	14	210.81	
AB	2	9.99	1.004
AS	14	5.94	
BS	28	118.87	
ABS	28	9.95	
TOTAL	89		

*($p < .05$)

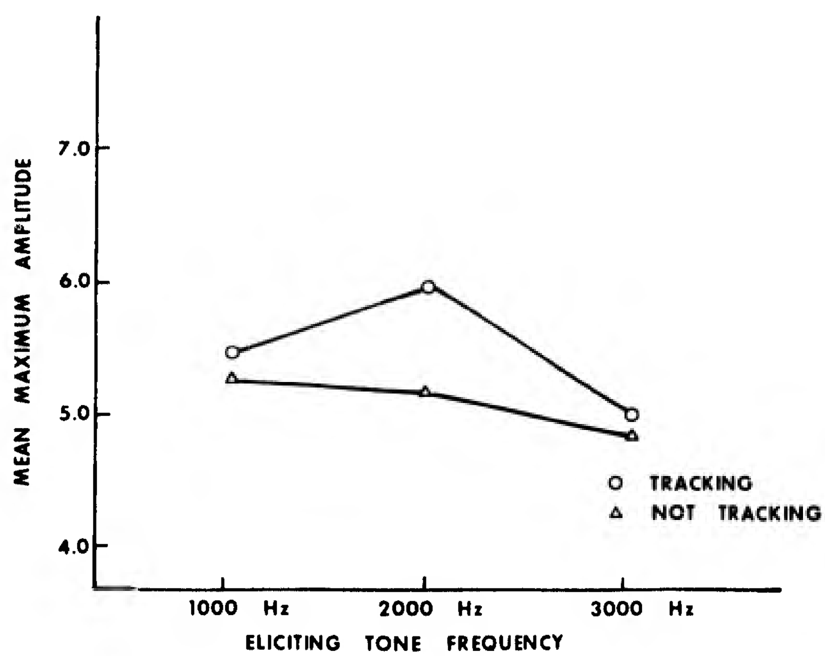

Fig. 2. Mean maximum amplitudes, Experiment II.

this mediator. The resulting efferent product adds to the fatigue products and thus produces decreased sensitivity. Since a stimulus is necessary to elicit the chemical mediator, no decrease in sensitivity will take place unless stimulation is present. Therefore, they predict no change in sensitivity without both auditory stimulation simultaneous with mental activity. Although the mental activity to which they referred was mental arithmetic, one might argue that tracking an auditory threshold might produce similar fatigue products to those suggested by Wernick and Tobias (28). The tracking frequency used by Smith and Loeb (25) was 1000 Hz while that employed in Experiment II was 250 Hz. It seems quite possible that the effect of tracking on the AR might be a function of the particular frequency being tracked and that inhibition of the AR might take place when higher tracking tones are used. This indicates the necessity of further research in which the tracking tone is varied in frequency in order to determine whether or not the effect of tracking on the AR is frequency specific. Although this does not explain the results of Experiment II, it is intended to suggest possible reasons for the results obtained by Smith and Loeb (25). The results of Experiment II remain as of yet unexplained. Arousal level may be a contributing factor, but this can only be determined by future research in which the level of arousal is controlled by drugs or other means.

SUMMARY AND CONCLUSIONS

Two experiments were conducted in which the main objective was to measure the effects of attention demanding conditions on the magnitude of the acoustic reflex (AR). This was done in order to test the notion of inhibition of the AR while listening for faint clicks or tracking a threshold level tone. In the first of these, subjects were required to detect faint signals in either phone ear or probe ear while the AR was being elicited. The control condition consisted of just remaining alert but not listening for a signal during the reflex elicitation. The results of this experiment do not demonstrate any significant effect on the magnitude of the AR due to listening for faint clicks in either contralateral or homolateral ear. In the second experiment, subjects tracked a 250 Hz threshold level tone before and during eliciting tones in the same ear and in the other condition merely remained alert during the elicitation. Results of this experiment show the magnitude of the AR to be significantly ($p < .05$) larger when the subjects track a tone than in the control condition. This suggests that the results obtained by Smith and Loeb (25) which show an increase in TTS for subjects tracking a tone while exposed to loud noise may possibly be better accounted for on the basis of some more central factor such as that described by Wernick and Tobias (28) rather than an inhibition of the AR (25). However, since the tracking tone used by Smith and Loeb (25) was 1000 Hz while that employed in this experiment was 250 Hz, it might also be possible that the effect of tracking on the magnitude of the AR may be frequency selective. Since this is only speculation, further research is needed to determine whether or not the effect of tracking on the AR differs from one tracking frequency to another. In this way, a more direct comparison can be made with the results of Smith and Loeb (25) who used a 1 KHz tracking tone and Collins and Capps (4) who used a 500 Hz tracking tone.

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APPENDIX A

Apparatus for Experiment I

The apparatus (Fig. 3, next page) consisted essentially of an Acoustic Impedance Meter (12), a simple digital programming system composed of BRS modules (1-11), a General Radio Wave Analyzer (13) used as a rectifier, a computer of average transients (14), and an X-Y recorder (15).

The eliciting tone is supplied to the earphones (17) when relay K1 operates. This relay is controlled by the programming system such that it operates for 1 second, starting 2 seconds after the operate button (S1) is pressed. A ready light is presented during that 2-second period prior to the eliciting tone. The sequence of operation is as follows when switches S2 and S3 are as shown in Figure 3: When switch S1 is pressed, one shot (1) triggers on for 2 seconds, thereby causing the warning lamp to light for that period. At the end of the warning period, the next one shot (2) is triggered on for 1 second, energizing relay coil K1, causing the K1 contacts to switch the eliciting tone output of the Madsen acoustic impedance meter to the earphones. After 1/2 second has elapsed, one shot (4) triggers one shot (6) on for .01 second, thereby energizing relay K2. This opens the by-pass around resistor R1, causing a .01 second drop in the eliciting tone. (This is the phone signal.) After the .01 second period, K2 is de-energized and the normal eliciting tone continues for the remainder of the 1-second period. If switch S2 is put in position B, relay K2 would not be energized during the .01 second signal period. Instead, the eliciting tone would be uninterrupted and a trigger pulse from one shot (1) would cause the sweep of the CAT to trigger and the normal reflex would be recorded. If switch S3 is put in position B and switch S2 is put in position A, relay K3 would be energized during the .01 second period, causing an interruption in the probe tone. The output of the acoustic reflex meter (12) passes through a rectifier (13) to a computer of average transients (CAT) (14) where it is accumulated. When desired, the contents of the CAT are plotted on the X-Y plotter (15).

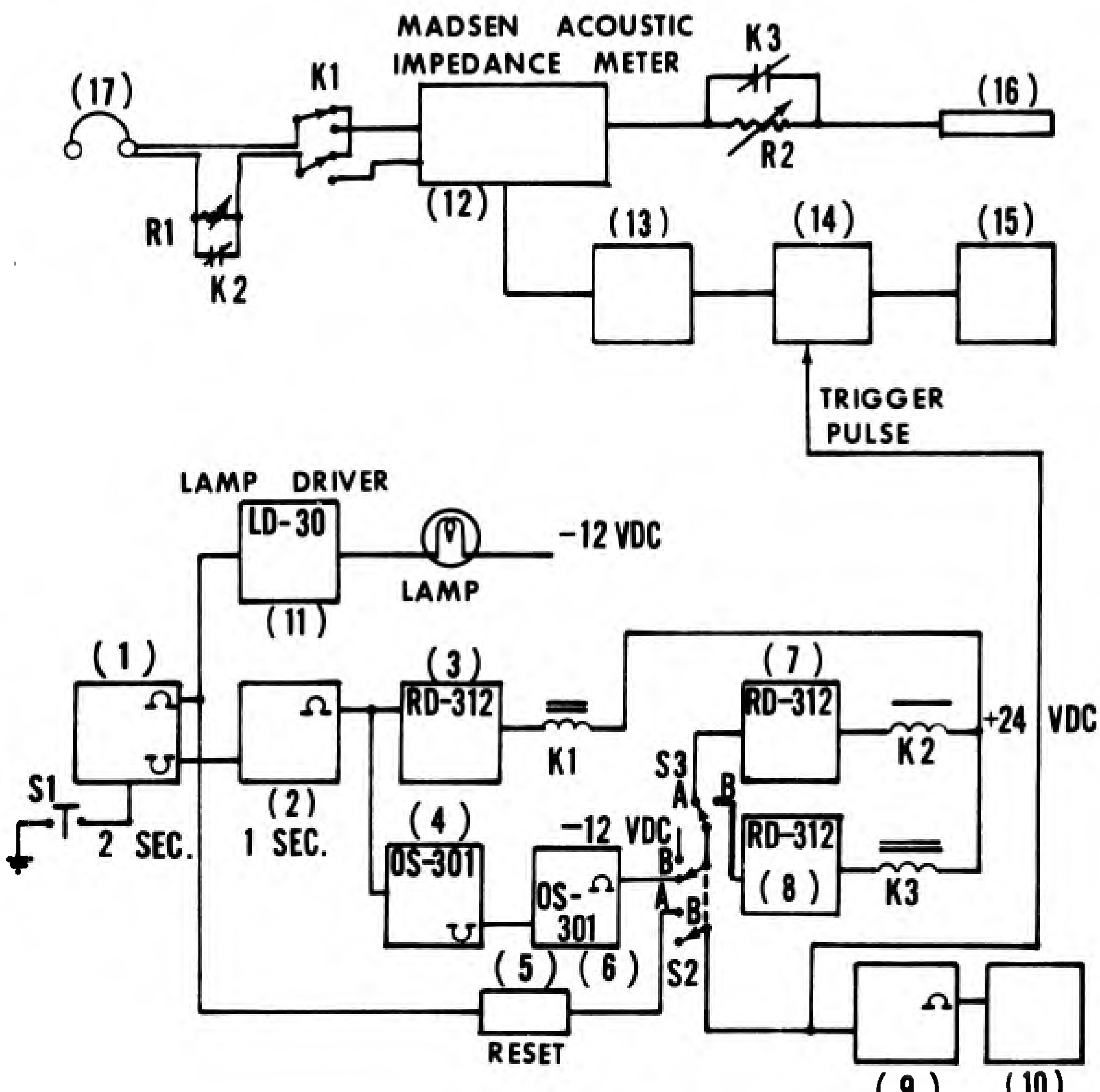

Fig. 3. Block diagram of apparatus used in Experiment I.

APPENDIX B

Madsen Acoustic Impedance Meter (Model Z 061)

The instrument has three main sections. The first is a pure tone audiometer connected to a single dynamic earphone (TDH-39) mounted on a special headset. For muscle reflex threshold measurement, the audiometer and earphone provide the stimulus to the ear under observation. The second section (impedance measurement section) consists of a pure tone generator having a fixed frequency of 220 Hz and is connected to a telephone in the ear probe unit forming part of the headset. A tube from the telephone conveys the pure tone to the meatus where an air-tight cavity is formed by a special rubber ear piece into which the probe is inserted. The tone is reflected by the eardrum and a second tube conveys it back to a microphone in the probe unit. By means of a phase/amplitude mixer, filter and amplifier, the reflected signals gives a visual deflection on an indicator meter, which in conjunction with the various controls, enables the stimuli to be varied and the reflex to be measured. The third and last section is a pressure control system comprised of a pump and manometer connected by flexible tubing to the probe unit. A tube in the probe conveys the pressure to the air-tight cavity in the meatus. The pump is used to vary the pressure in the meatus above or below atmospheric pressure, although it was used in these experiments chiefly to verify an air-tight seal of the probe in the meatus.

APPENDIX C

Apparatus for Experiment II

The apparatus for this experiment (Fig. 4, next page) consisted essentially of an acoustic impedance meter (4), a tracking attenuator (6), a mixing circuit (5), a rectifier (10), a computer of average transients (CAT) (11), an X-Y plotter (12), and a simple digital programming system (1), (2), and (3).

When switch S1 is pressed, one shot (1) triggers the CAT (11). After 1 second, one shot (1) triggers one shot (2) which energies relay driver (3) for 15 seconds. Relay driver (3) in turn, operates relay K1 which connects the eliciting tone output of the acoustic impedance meter (4) to the mixing circuit (5). There, the eliciting tone is mixed with the tone the subject has been tracking. The output of the acoustic reflex meter (4) passes through a rectifier (10) to a computer of average transients (CAT) (11), where it is accumulated. When desired, the contents of the CAT are plotted on the X-Y plotter (12).

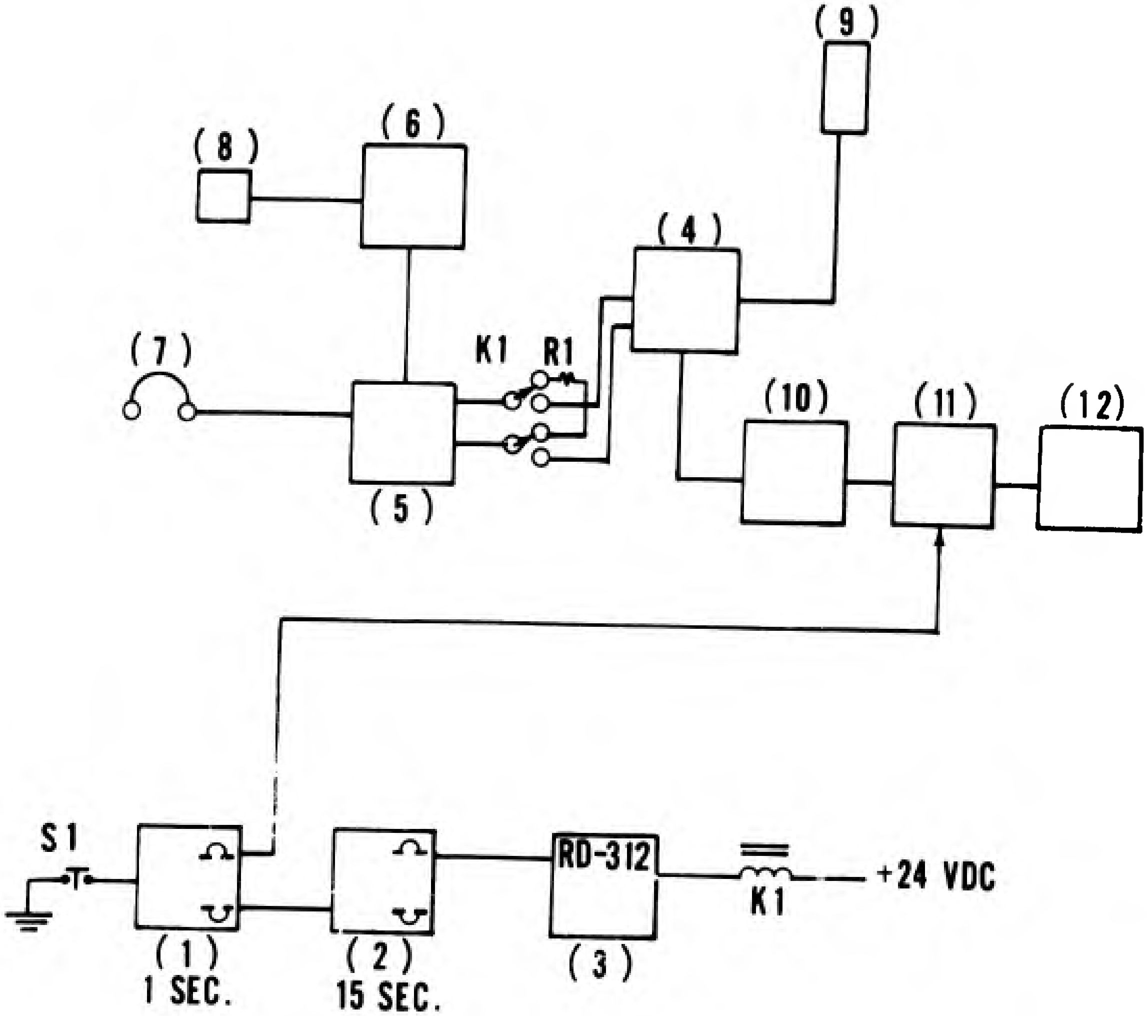

Fig. 4. Apparatus used in Experiment II.

APPENDIX D

Data

TABLE 9

Areas of Reflex Plot, Experiment I

Session	I			II			III		
Condition	1	2	3	1	2	3	1	2	3
Subject 1	138	174	94	172	278	292	272	231	138
2	85	27	122	76	57	50	91	12	35
3	79	48	215	239	290	181	184	43	195
4	136	55	95	48	213	77	115	146	64
5	83	90	82	70	107	139	114	137	55
6	135	195	107	85	42	86	220	117	88
7	124	63	82	197	115	127	179	222	227
8	88	158	141	56	46	45	185	57	24
9	154	106	103	113	101	184	275	271	333
10	102	75	135	287	199	163	186	180	188
11	229	53	102	74	125	81	114	81	175
12	86	136	149	64	73	72	75	44	157
13	117	220	63	120	126	162	68	61	29
14	95	43	110	218	115	161	117	76	112
15	35	46	29	103	68	55	189	101	80

TABLE 10

Maximum Amplitude, Experiment I

Session	I			II			III		
Condition	1	2	3	1	2	3	1	2	3
Subject									
1	8.0	11.0	6.0	18.7	18.5	19.0	18.0	17.0	13.0
2	7.5	4.0	8.5	5.0	6.0	3.0	7.0	1.5	2.0
3	5.0	3.5	11.5	15.0	18.0	13.0	13.0	4.0	13.0
4	6.0	5.0	7.0	3.5	16.0	6.5	9.0	13.0	7.0
5	7.0	4.5	4.8	5.5	7.5	9.0	12.0	13.0	4.0
6	10.0	12.5	8.0	7.5	4.5	8.0	18.5	10.0	10.0
7	8.0	4.5	5.0	15.5	9.5	12.0	15.0	16.5	17.0
8	5.0	8.0	9.5	5.0	3.0	3.0	11.5	5.0	2.5
9	7.5	5.5	5.5	10.0	7.0	14.0	14.5	16.5	22.0
10	6.5	5.0	9.0	21.5	15.0	12.5	14.0	13.0	14.0
11	12.5	4.0	6.0	8.0	11.0	10.0	8.0	7.0	12.0
12	8.5	10.5	13.5	8.5	8.0	8.0	7.5	3.5	11.5
13	11.0	15.0	6.0	10.0	11.5	15.0	7.5	7.5	2.5
14	8.0	5.5	9.0	18.0	11.5	15.0	10.0	8.5	8.5
15	4.0	5.0	3.0	10.0	8.0	5.0	13.5	9.5	9.5

TABLE 11

Areas of Reflex Plot, Experiment II

Condition	Set 1		Set 2		Set 3	
	4 (tracking)	1 (not tracking)	5 (tracking)	2 (not tracking)	6 (tracking)	3 (not) tracking)
Subject 1	249	249	276	210	270	245
2	230	268	98	52	54	45
3	116	77	124	106	99	90
4	156	106	145	98	95	108
5	120	132	134	116	106	119
6	85	82	43	80	66	52
7	76	94	162	123	139	115
8	108	108	64	84	72	57
9	98	69	72	130	98	56
10	100	102	278	245	85	140
11	101	88	67	50	46	80
12	102	74	134	108	95	137
13	83	116	152	104	70	54
14	111	60	82	49	78	89
15	68	96	92	110	135	90

TABLE 12

Maximum Amplitude, Experiment II

Condition	Set 1		Set 2		Set 3	
	4 (tracking)	1 (not tracking)	5 (tracking)	2 (not tracking)	6 (tracking)	3 (not tracking)
Subject 1	5.2	3.5	5.5	4.5	4.4	4.0
2	6.8	5.0	6.5	4.3	4.3	5.0
3	3.5	4.5	4.1	4.8	6.2	4.5
4	3.7	5.3	7.0	4.7	4.0	3.3
5	4.0	3.8	2.1	3.7	4.1	4.0
6	4.3	4.0	3.2	2.9	2.4	4.0
7	10.0	11.7	4.6	2.6	3.0	2.2
8	4.4	4.5	12.2	11.5	4.0	6.3
9	4.4	3.2	3.8	5.7	5.1	3.2
10	3.7	4.3	7.1	5.5	6.1	5.2
11	4.8	3.6	6.0	4.8	4.7	6.5
12	11.2	11.1	12.4	9.4	12.2	11.2
13	5.4	5.3	3.9	4.4	4.3	3.0
14	5.5	6.0	6.0	5.1	4.8	5.6
15	5.3	3.3	5.4	3.8	5.3	4.7

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13. ABSTRACT

In order to test the hypothesis that the acoustic reflex (AR) is inhibited while subjects listen for faint signals or while they track their threshold for a 250 Hz tone, two experiments were conducted in which the main objective was to measure the effects of attention demanding conditions on the magnitude of the AR. In the first of these, subjects were required to detect faint signals (threshold level clicks) in either phone ear or probe ear while the AR was elicited by a one second, 1500 Hz tone. The control condition consisted of merely remaining alert but not listening for a signal during the reflex elicitation. The results of this experiment did not demonstrate any significant effect of listening for faint clicks in either contralateral or homolateral ear on the magnitude of the AR. In the second experiment, subjects tracked a 250 Hz threshold level tone before and during eliciting tones of 15 seconds duration in the same ear. In the control condition, they merely remained alert during the elicitation. Results of this experiment showed the magnitude of the AR to be significantly ($p < .05$) larger when the subjects tracked the 250 Hz tone than when not tracking. These results do not support the notion of inhibition of the AR by subjects listening for faint sounds (Smith and Loeb, 1967). (U)

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Vigilance						
Acoustic Probe						
Physiological Indices						