EFFECT OF MASKING AND FATIGUE ON ACOUSTIC REFLEX THRESHOLD (ART)*

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Introduction

Masking and fatigue are two different processes (Ward 1963). Masking represents the change of threshold for one auditory stimulus concurrently with the presentation of a second stimulus. For example, a subject has a threshold of lOdB at 4 KHz, in the presence of a broad-band noise at 80dB SPL his threshold of hearing at 4 KHz may increase to 50dB HL. Here, the difference in the thresholds at 4 KHz (40 dB) is referred to as the threshold shift brought about by the masking noise. The threshold in the presence of the noise is referred to as masked threshold. Masking is regarded as a ' line-busy' phenomenon and as such there is a great deal of neural activity.

Auditory fatigue represents the change of threshold following exposure to auditory stimulus. In contrast to masking, auditory fatigue is a ' *line-dead'* phenomenon as the neural elements either are *temporarily incapable of being fired or at least at* refractory period (Ward 1963). Here the neural activity is much less unlike in masking.

Despite the difference between the two, they have a common factor viz., bringing a change in the ability to detect a particular auditory signal.

Having known that masking and fatigue are two different processes and that both of them produce threshold shifts, seme studies (Tonndorf *et ah,* 1955, Sherrick 1959, Small and Minifie 1961 b; Harris 1947-48, Brandt 1963)have been reported regarding their effects on differential thresholds for intensity and differential thresholds for frequency. Masking and fatigue have been observed to have different effects on the above parameters. For example, if a 1000 Hz tone at 60 dB SL (re: normal threshold) has a differential threshold of 2 dB with enough noise to shift the normal threshold by 40 dB, the differential threshold will be increased. However, if the level of the tone is raised in the presence of noise so that it is 60 dB SL (re: masked threshold) the differential threshold will still be 2dB (Small, 1963). According to Elliott *et ah,* (as reported by Small, 1963) if the same threshold shift is brought about by fatigue, the DL for intensity at 60 dB SL (re: to TH after fatigue) will not be 2 dB, but something significantly less.

The present investigation ' Effect of masking and fatigue on acoustic reflex threshold ' was conducted to establish whether there was any significant difference in their effects on ART in normals.

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Method

Subjects: Five normal hearing subjects in the age range of 17 to 23 years were selected for the study. All the subjects had normal hearing (20 dB ISO 1964) for frequencies from 250 Hz to 4 KHz.

Apparatus: Pure tone audiogram was taken for all the subjects using Arphi Model IV audiometer (ISO 1964). The audiometer was calibrated using B and K equipment.

Impedance measurements were done using an Electro-acoustic impedance bridge (Madsen model Z070). It was calibrated using B and K equipment.

Procedure

Testing was done in a sound treated room which satisfied the maximum allowable noise levels prescribed.

Experiment No. 1: *Effect of masking on acoustic reflex thresholds:*

1. Pure tone audiogram was taken for both the ears for frequencies from 250 Hz to 4 KHz.
2. Acoustic reflex thresholds of right ear were measured for the frequencies 2 KHz and 4 KHz.
3. Masking noise (wide band) was presented to the right ear at 84 dB SPL and masked thresholds for 2 KHz and 4 KHz were determined.
4. Acoustic reflex thresholds of right ear were measured in the presence of ipsilateral masking (84dB SPL) for frequencies 2 KHz and 4 KHz.

Experiment No. 2: *Effect of fatigue on acoustic reflex thresholds*

1. Wide band noise at 124 dB SPL was presented to the right ear for thirty minutes continuously,
2. At the end of thirty minutes' exposure time, the noise was cut off. The thresholds for frequencies 2 KHz and 4 KHz were determined soon after the termination of the noise. TTS for the frequencies 2 KHz and 4 KHz was computed.
3. After a recovery time of one minute the acoustic reflex thresholds were determined i.e., finding the minimum intensity of the tones (2 KH_a and 4 KHz) required for the right ear to elicit the reflex,

Experiment No. 3. *Reliability check*

To check the reliability of the results obtained in Experiment No. 1 and Experiment No. 2, the experiments were repeated to the three subjects and the results were statistically analysed.

Results

Table 1 gives the acoustic reflex thresholds at 2 KHz and 4 KHz for all the five subjects under the two conditions. (1) with ipsilateral masking and (2) after the ear was fatigued. Retest values are also indicated.

Table 2 gives the masked thresholds and TTS in all five subjects. Retest scores are also included.

In Table 3 Mean and Standard deviation values and interpretation are presented for the air conduction threshold shifts produced at 2 KHz and 4 KHz by ipsilateral masking noise and also for TTS produced at 2 KHz and 4 KHz by fatiguing stimulus.

The analysis of the data shows that there is no significant difference between test and retest scores in either of the two frequencies with respect to either shifts produced by ipsilateral masking or TTS produced by fatigue.

Table 4 shows that there is significant difference between the Mean ART (Acoustic Reflex Threshold) with noise and the Mean ART after fatigue at both the frequencies. Statistical analysis was done to see whether there was any significant difference in the results between the frequencies tested. The results showed that there was no significant difference in the results obtained at 2 KHz nd 4 KHz. The effects of masking and fatigue on ART are illustrated in Figure 1.

TABLE I

	Test Scores				Retest Scores			
	ART with noise		ART after fatigue		ART with noise		ART after fatigue	
	2K	4K	2K	4K	2K	4K	2K	4K
A	95 (95)	95 (95)	115 (95)	120 (95)	—	—	—	—
B	90 (90)	100 (100)	110 (90)	115 (100)	85 (85)	85 (85)	95 (85)	105 (85)
C	95 (95)	105 (105)	105 (95)	120 (105)	—	—	—	—
D	95 (95)	95 (95)	105 (95)	105 (95)	100 (100)	90 (90)	120 (100)	115 (90)
E	90 (90)	100 (100)	100 (90)	110 (100)	90 (90)	100 (100)	100 (90)	110 (100)

Numbers in the parenthesis indicate acoustic reflex thresholds measured in the absence of ipailateral masking noise and before the ear was fatigued.

TABLE 2

Subjects	Test Scores: Shift in THS produced by Ipsilateral masking		Test Scores: T.T.S. after fatigue		Retest Scores: Shift in THS produced by ipsilateral masking		Retest Scores: T.T.S. after fatigue	
	2K	4K	2K	4K	2K	4K	2K	4K
A	35	40	40	40	—	—	—	—
B	40	35	45	35	20	40	25	60
C	40	35	30	30	—	—	—	—
D	25	30	15	35	25	30	20	35
E	35	55	25	65	50	35	50	60

TABLE 3

	Mean	S.D.	N	t	Interpretation
1. Shifts in THS produced by ipsilateral masking at 2 KHz					
Test	35.00	6.1[illegible]	5	.44	*
Re-test	31.66	16.07	3	0.44	t
2. Shifts in THS produced by ipsilateral masking at 4KHz					
Test	39.00	9.61	5	.66	*
Re-test	35.00	5.00	3	0.66	t
3. TTS produced by fatiguing stimulus at 2 KHz					
Test	31.00	11.9	5	.66	*
Re-test	31.66	16.07	3	0.66	t
4. TTS produced by fatiguing stimulus at 4 KHz					
Test	41.00	13.8[illegible]	5	.98	*
Re-test	5100	5.05	3	0.98	+

• No significant difference at .05 level
t No significant difference at .01 level

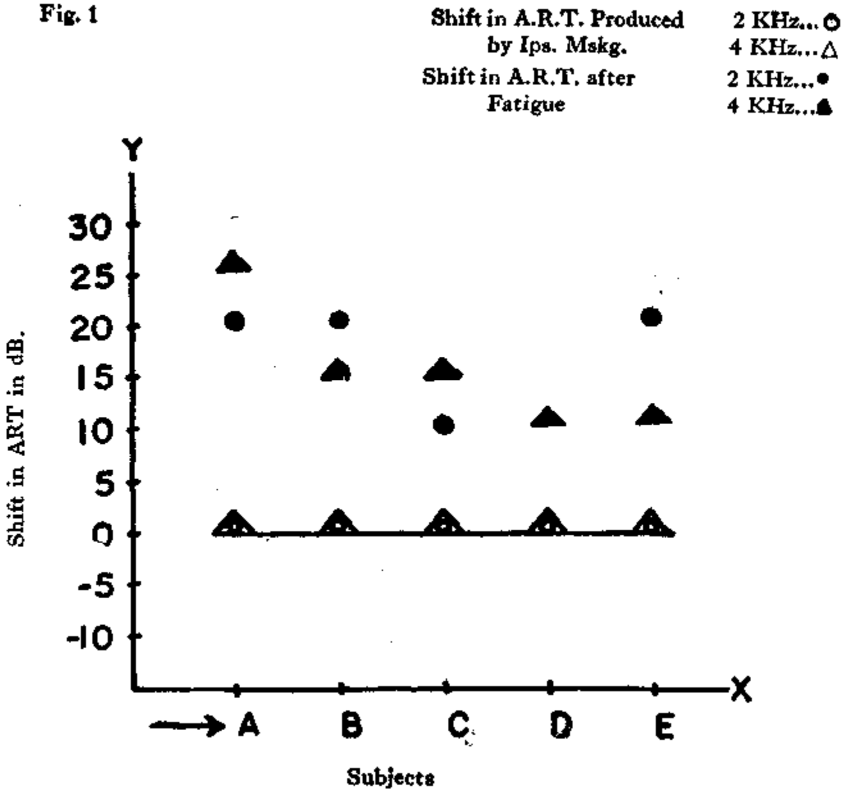
TABLE 4

	Mean	S.D.	N	t	Interpretation
1. ART with noise at 2 KHz	93.00	2.7[illegible]	5	7.20 7.20	*
2. ART after fatigue at 2 KHz	109.00	4.18	5		t
3. ART with noise at 4 KHz	99.00	4.1[illegible]	5	4.36	*
4. ART after fatigue at 4 KHz	114.00	6.52	5	4.36	t

• Significant difference at .05 level
f Significant difference at .01 level

j

Fig. 1



Discussion

The results show that there is no significant difference in the acoustic reflex threshold measured in the presence of ipsilateral masking and in the absence of ipsilateral masking noise. This indicated that masking had no effect on acoustic reflex threshold. On the other hand, the results on the effects of fatigue on ART showed that there was significant difference in the acoustic reflex thresholds measured before and after fatigue. The shift in ART is not in proportion to the threshold shifts produced by the fatiguing stimulus. The mean shifts in ART are 16 dB and 15 dB at 2 KHz and 4 KHz respectively whereas the mean shifs in thresholds are 31 dB and 41 dB at 2 KHz and 4 KHz respectively. In subject 'E', TTS at 4 KHz is 60 dB whereas the shift in ART is just 10 dB at 4 KHz. The above finding indicates that the shift in ART may not be related to the shift in the absolute thresholds brought about by fatigue in the cochlea. So it appears that the shift in ART after the ear is fatigued may be due to the fatigue of the tympanic muscles.

To verify whether the shift in ART after the ear is fatigued is due to the fatigue of the tympanic muscles alone, acoustic reflex thresholds of non-fatigued ear (left ear) measured before and after the fatigue of the right ear were compared. The rationale for this experiment was based on the fact that monaural stimulation results in bilateral reflex. Consequently, the tympanic muscles of the ear contralateral to the fatigued ear should also undergo fatigue even though the fatiguing stimulus is not presented to that ear. It was found that there was no difference in acoustic reflex thresholds of the non-fatigued left ear before and after the right ear was fatigued. However the failure to observe any shift in ART in the non-fatigued ear may be due to the delay in the measurement of the reflex of the non-fatigued ear. To measure the reflex of the non-fatigued ear the probe tip had to be inserted to the fatigued ear and tone had to be presented to the non-fatigued ear. Removing the earphone kept on the fatigued ear and inserting the probe tip to the same ear takes some time. Probably this delay may be responsible for the absence of any shift in ART in the non-fatigued ear. It is known that a momentary rest is enough for the middle ear muscles to regain their contractile strength. The above problem can be overcome if the impedance bridge having provision for ipsilateral reflex is used.

An alternative method to verify whether the shift in ART in the fatigued ear is due to the fatigue of the tympanic muscles alone or not is to study the recovery pattern of ART and absolute threshold in the fatigued ear. If the shift in ART in the fatigued ear is due to the fatigue of the tympanic muscles alone, there should be complete recovery of ART within a short time. It was observed that the shift in ART was maintained for more than 30 minutes. However, the study of recovery pattern of TTS and ART after the ear is fatigued was not studied in detail. This has to be dealt with separately.

Conclusion

Masking and fatigue influence ART differently. The former has no significant effect on ART whereas the latter increases ART. The shift in ART of the fatigued ear is not in proportion to the TTS produced in the fatigued ear. The mean shifts in ART are 16 dB and 15 dB at 2 KHz and 4 KHz respectively. The mean shifts in thresholds are 31 dB and 41dB at 2 KHz and 4 KHz respectively.

The findings: (1) No change in the shift of ART of the fatigued ear during 20-30' of recovery time and (2) no change in the ART of the non-fatigued ear when measured before and after fatigue indicate that the shift in ART of fatigued ear may not be due to the fatigue of the tympanic muscles alone even though the shift is not in proportion to the TTS.

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