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THE ROLE OF ATTENTION IN SOUND PERCEPTION

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1. INTRODUCTION

The question of how attention, or more precisely a lack of attention can affect the perception of sounds is of particular relevance to a consideration of the perception of unexpected warning sounds. The current study arose in the context of the specific question of how the wearing of hearing protectors may affect the ability of the wearer to perceive warning and other important machinery "indicator" sounds. More generally an understanding of the role of attention could provide guidance on the specification of effective warning sounds to include their loudness and their spectral and temporal characteristics. This would be of particular use to a number of organizations currently considering the standardization of warning sounds.

Three separate questions need to be answered in considering whether a warning sound will be perceived:

(1) Can it be heard? i.e. its audibility.
(2) Will it be heard? i.e. whether it will command the persons attention.
(3) Will it be recognized? i.e. whether the meaning of "impending danger" will be communicated to the person.

The experiment to be described in this paper focuses on the second question, the attention demand of a sound. In a previous paper we have considered the first question, the audibility of warning sounds (1). Current experimentation is investigating the third question, the recognition of warning sounds in realistic noise environments.

There exists a divergence of opinions as to whether inattention can in fact lead to important sounds not being perceived. Typifying one school of thought is the description of hearing as "the sentinel of our senses" (2). Anecdotal evidence is usually cited to support this view that inattention will not affect our perception of important sounds. Examples often cited include the ability of mothers to hear even the faintest babies' cry, and hearing ones own name in the babble of voices at a cocktail party. Hearing is clearly more vigilant than vision, there being no equivalent to looking the wrong way or having one's eyes closed. The alternative view is based on limited experimental evidence which suggests that the threshold of sound may be elevated through inattention by anything from 4 to 20 dB (3,4,5). The methodology used in these studies was however unsatisfactory on a number of points casting doubt on the validity of their findings.

In view of these doubts an experiment was conducted to investigate whether temporal uncertainty and a loading task could cause a change in response rate to a typical warning sound in a background noise.

2. PROCEDURE

The experiment investigated a single warning sound and noise combination using four presentations of the signal at each of five different levels in a random order and at random intervals. Each subject attended one session during which he performed a loading task, and another session under vigil conditions, the order of conditions being suitably randomised across the subjects. In fact two further sessions repeated these conditions with the subject wearing hearing protectors, however this aspect of the data will not be discussed here. The background noise was broad band random noise at a level of 75 dB SPL, and the warning sound was a tape-recording of an electromechanical siren, the 5 second presentation including the distinctive run-up and run-down of such devices. Both the noise and the warning sound were presented via a single loudspeaker to the subject in an anechoic room.

The loading task used was a modified version of a television game, a similar task having been used by Scharf in a different context (6). The subject controlled a bat and attempted to direct a ball through a moving hole. A number of parameters could be varied so as to adjust the difficulty of the task. Subjects were instructed to try to win by as many sets as possible and were encouraged in their performance at the task by continuous feedback of the points score and at both the task and responding to the sound by a financial bonus awarded at the end of the experiment based on their overall performance. The measures recorded during the experiment were the number of responses to the warning sound , the response time and when appropriate the performance at the loading task.

Prior to the experimental sessions the subjects were tested for normal hearing, briefed on the experiment and given practice at the television game and also the auditory task. Each experimental session started with a further briefing, game practice and familiarisation with the warning sound. The pre-test threshold of the warning sound was measured using a random ordered method of limits. During the main session the "effective threshold" was measured using a similar method but with the signals presented at random intervals with a mean inter-signal interval of 90 seconds (and range 20 to 180 seconds). At the end of the main session the post-test threshold was measured using the same method as for the pre-test threshold measure.

3. RESULTS AND DISCUSSION

There was no significant change between the pre- and post-test threshold measures so these were combined into a single mean masked threshold measure. The results in terms of mean number of responses versus signal level are shown in Figure 1. The curves show the typical S-shaped form of psychometric functions, rising from a chance rate at 55 dB signal level to 100% response rate at 75 dB signal level. The responses to the inaudible 55 dB signal level presentations can be taken as a measure of the false alarm rate. There were, in addition, spontaneous responses unrelated to any signal presentation at a frequency similar to the response rate to the 55 dB signals. These would not however have influenced the recorded number of responses appropriate to each signal level. A 50% response rate threshold can be interpolated at approximately 62 dB signal level.

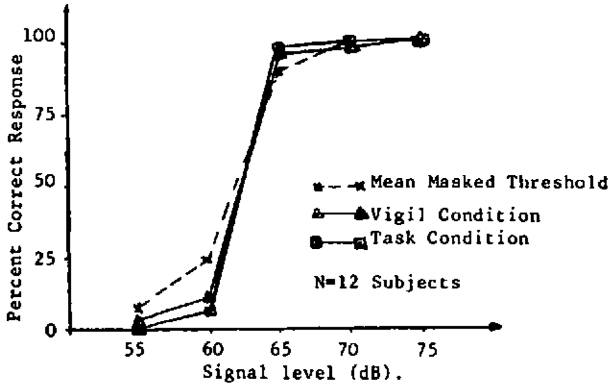
It is apparent that there were no large differences between the mean masked threshold measure and either the loading task or vigil effective threshold measures. The difference at 60 dB is significant ($p < 0.01$ Tukey's test) and indicates that for the sub-threshold sound there may be a slightly reduced response rate during both the vigil and task conditions. However for the supra-threshold sounds there was no evidence of a threshold elevation.

The mean response time data shown in Figure 2 indicates consistent differences between the listening conditions. During the vigil condition the response times were on average 0.12s longer than during the masked threshold measures, whereas during the task condition they were 0.23s longer, both differences being highly significant ($p < 0.001$). This suggests that the temporal uncertainty added a significant latency to the response process, and the combined task loading plus temporal uncertainty caused almost twice this increase, without apparently affecting the number of responses made.

There was some suggestion that the subjects who responded most quickly during the main session also responded to the greatest number of signals, the regression accounting for 32% of the variance ($r = 0.56$, $p < 0.001$).

Examination of the task scores in terms of a points difference measure (the points won minus the points lost per 5 minute interval) showed wide intersubject variability. Plotting this points difference score against the total number of points in Figure 3 highlights the different strategies used by the subjects. For example subject 2 won by many points, winning and losing points relatively quickly, whereas subjects 5 and 12 won by almost as many points but with considerably longer rallies. This suggests that the parameters represent measures of skill and strategy respectively.

Fig. 1. Mean number of responses versus signal level for different listening conditions.



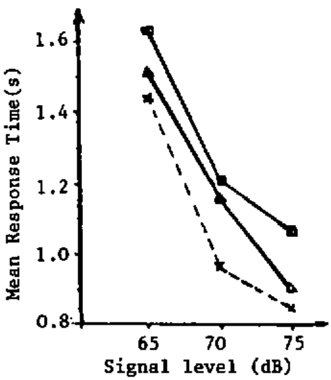


Fig. 2. Mean response times versus signal level for different listening conditions.

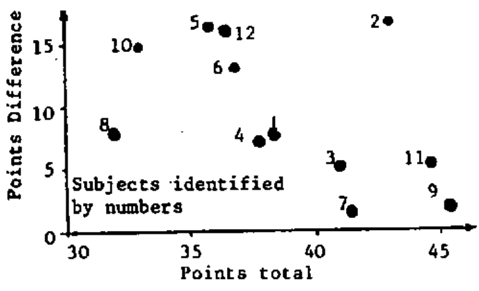


Fig. 3. Relationship between task scores.

There was no marked correlation between performance at the task and the number of responses to the warning sound. For example it can be seen in Figure 3 that those subjects who had elevated thresholds (subjects 1,2,4,6,9, 10 and 11) had a range of skills and adopted a range of strategies to the task. There was however some suggestion that those subjects who performed better at the game responded more quickly to the signals during the main session, the regression accounting for 37% of the variance ($r = 0.61$, $p < 0.01$).

4. CONCLUSION

The results of the experiment suggest that inattention will not necessarily reduce the probability of the perception of an unexpected but important sound. This finding is however specific to the experimental conditions used, most notably the use of relatively long signal duration, short session duration, short inter-signal intervals, and with subjects involved in an interesting psycho-motor task. A more general conclusion would require varying these conditions to encompass a wider range of situations. The results do however suggest that inattention can markedly prolong response times both due to temporal uncertainty and a loading task. Whilst delayed responses to a warning sound may in some situations be a hazard, the delays of 0.1 to 0.2 seconds observed here would not be of importance in most situations.

The differences between the findings of this study and those which have previously reported an elevation of threshold may in part be due to methodological differences, but more importantly may depend on the motivation of the respective subjects. The subjects in this study were encouraged to perform well at both the loading task and the auditory task, whereas previous studies may have placed excessive emphasis on performance at the loading task. These results therefore support the view that detectable sounds of importance to a person can be equally well perceived under conditions of inattention.

5. REFERENCES

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