Effects of Sustained Attention on Auditory Displays, Mental Workload, and Stress

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Background

Vigilance can be defined as the sustained attention required in detecting transient and infrequent signals over an extended period of time (Warm, 2003). The current research defines these infrequent signals as "critical signals" indicating that an abnormal event is taking place. We are mainly concerned with the decrement of vigilance over time caused by an increase in cognitive load due to the constant monitoring of like, or "neutral," signals (Parasuraman, 1979). The relevance of this research is that many professions (e.g., air traffic control) require sustained monitoring to detect changes in signals, including auditory tones. There is a potential for catastrophic events, such as the fatal crash of an airplane, if a critical auditory signal is missed by an air traffic controller. Therefore, studies of the factors affecting the monitoring of auditory signals will continue to focus on the ability of people to accurately perform sustained attention tasks.

Hypotheses

- Sounds that are presented in the same pitch, frequency, and amplitude binaurally (to both ears) will be perceived as localized central to the median plane (a location analogous to a geometrical plane passing through the middle of the head, front to back), whereas sounds that are presented in the same pitch and frequency to each ear, but a higher amplitude to one ear than the other, will be perceived as coming from the direction of the ear stimulated by the higher amplitude.
- Accuracy (vigilance) will decline more rapidly in the sound localization task as opposed to the detection of duration task due to an increase in mental workload for the localization versus the duration task.
- In the sub-tasks, accuracy will decline more rapidly in the tasks requiring participants to respond to critical signals with the same duration or spatial orientation amongst neutral signals which have different durations or spatial orientations due to an increased demand on mental capacity.

References

Parasuraman, R. (1979). Memory Load and Event Rate Control Sensitivity Decrements in Sustained Attention. *Science, 205*(4409), 924-927

Warm, J., Grier, R., Dember, W., Matthers, G., Galinsky, T., Szalma, J., & Parasuraman, R. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. *Journal of the Human Factors and Ergonomics Society*, *45*(3) *87-112*

Method

Undergraduate participants are first presented with two tasks intended to gauge limitations on responding accurately to critical signals. The first of these manipulates the duration of an auditory tone using two tones of equal loudness that last for different lengths of time. In this instance the critical signals are the tones that are of shorter duration. The second manipulates the spatial location of auditory tones, using the same tone as in the first task; although the tones are of equal duration, they are spatially presented at different locations in auditory space around a perceiver's head. In this instance, the critical signals are the tones that are off-center in relation to the head and heard mainly in one ear whereas neutral signals are central in relation to the median plane.

Duration Task

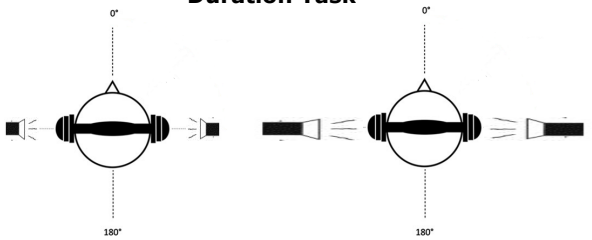

Figure 1: Neutral Signal (250ms Duration)

Figure 2: Critical Signal (500ms Duration)

Spatial Localization Task

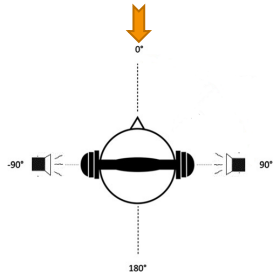

Figure 3: Critical Signal

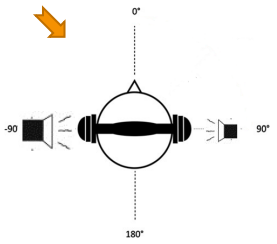

Figure 4: Neutral Signal

: Perceived direction of sound

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Method Continued

The participant's performance is averaged over a number of trials to determine the capacity to respond to critical signals. This information is used in follow-up tasks involving either the duration or spatial aspects. In follow-up tasks, equally often participants will be asked to make responses to neutral signals that are all the same as compared with different critical signals, or neutral signals that are all different as compared to critical signals that are the same. For example, in the spatial sub-tasks participants are asked only to respond to critical signals which present one sound localized central to the median plane (Figure 2) and one sound which will be perceived as coming from another direction (Figure 4) or vice versa.

Expected Results

Participants' accuracy will decrease more rapidly during the spatial localization tasks compared to the duration tasks. This decrement in ability to detect critical signals will come from the routinized behavior that Robertson cites in his 1999 experiment. The mental workload and stress will also increase more during the spatial localization tasks. The participants' workload will increase in the sub-tasks requiring in contrast with the adaptive tasks participants to respond to critical signals with the same duration or spatial orientation amongst neutral signals which have different durations or spatial orientations. This increase in workload can be expected from Parasuraman's 1979 research on auditory perception.

Implications

Future research on sustained attention tasks can be applied to many fields. Current research has been focusing on children with primary language development, narcoleptic patients, and ADHD sufferers who seek the natural ability to sustain their attention, but having difficulties doing so.

Investigations into the cerebral blood flow during vigilance tasks could make way for scientists and researchers to understand the allocation of nutrients to the cortex when performing tasks that require sustained attention. Measuring individual differences within sustained attention tasks has become a new frontier for research in human factors. Further investigation into the possibility of altering or increasing an individuals' attention span while simultaneously decreasing workload is another promising avenue of future research.