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Noise

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1pNSa3. Supplemental text messaging for the resolution of auditory overload.
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Military signal operators listen, transcribe, and respond to audio traffic over multiple audio channels, in high-level noise from vehicles and weapons. The messages typically overlap in time and may be difficult to disentangle. Two studies were carried out to determine the benefit of supplemental texting. Normal-hearing participants were tested in a mock up of a military command post. Brief messages were played simultaneously over a communications headset (dichotic) and a loudspeaker array, either in quiet or in a background of vehicle noise. The at-ear speech-to-noise ratio was 5 dB. Only those messages beginning with a pre-assigned call sign were encoded. Mean scores of 84% or better were observed for messages presented over the headset, although there was a clear right ear advantage in noise. Messages coming over the loudspeakers were more difficult to understand but a visual cue directing attention to the source of an incoming targeted message resulted in a significant improvement of 7%. Replacing audio messages over the loudspeakers in noise with visual or audiovisual presentations resulted in an improvement from 71% to 96% that did not negatively affect headset performance. The data suggest that texting is a viable option for communication in cases of degraded audio.

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INTRODUCTION

This research investigated divided listening over a communication headset with integrated hearing protection. It has been shown previously that listeners can understand a single talker among many (the “cocktail party effect”) but will have difficulty understanding competing talkers. Intelligibility may improve if the talkers have distinguishing characteristics such as their gender, vocal intensity, spatial location, or importance (e.g., Hawley et al., 1999; Drullman and Bronkhorst, 2000; Brungart, 2001; Arbogast et al., 2002; Drullman and Bronkhorst, 2004). Divided listening is common in military command and control operations where personnel may be required to monitor, encode, respond to and relay messages delivered concurrently from several networks over their communication headsets, over loudspeakers and by the live voice of crewmembers. The backgrounds vary and may include background noise from vehicles, weapons fire, aircraft flyovers and non attended conversation in the immediate vicinity. Two experiments were carried out. The first experiment determined the benefit of visual cues to direct attention to an audio channel delivering a targeted message. The second investigated the benefit of text compared with loudspeaker presentation of messages. Interference by text with the understanding of messages presented simultaneously over the headset was also assessed.

METHODS AND MATERIALS

Two different groups of English-fluent, normal-hearing males participated in the two experiments, respectively. All participants were fitted with a communications headset that is commonly used in Canadian Forces (CF) land vehicles. The headset attenuated the level of external sounds but did not affect the level of messages delivered over the headset. Active noise reduction capability, although available, was not activated for these studies. Participants were tested individually in a sound isolated room, seated in front of a laptop computer in a mock-up of CF vehicular command post. The test room contained an array of loudspeakers designed for the simulation of a wide range of CF noise environments, in terms of both level and spectrum. Within the mock-up, a set of four loudspeakers suspended from the framework and level with the top of the head surrounded the participant at an approximately 45-degree angle on either side of the midline, front and back, at a distance of 1 metre. These along with the headset were used to present the messages. A monitor speaker located directly behind the participant was used to present speech babble noise which modelled the overlapping conversation of multiple talkers.

The messages used in both studies were taken from the Coordinate Response Measure (CRM), a non standardized set of phrases for multi-talker communications research, adapted by Bolia et al. (2000). Each phrase consists of a recording of a talker speaking a call sign following by a colour-number combination within a carrier phrase, e.g., “Charlie go to Red Four now”. In all, there are 256 phrases derived by combining eight possible call signs, four colours and eight numbers. Recordings by four male and four female talkers are available.

Experiment 1 (Abel et al., 2012)

There were sixteen listening conditions consisting of combinations of quiet or 70-dBA at-ear vehicle noise, absence or presence of 70 dB SPL at-ear speech babble, the number of audio channels - two or three (loudspeakers surrounding the head and diotic headset or loudspeakers and dichotic headset), and the absence or presence of visual cueing of the channel carrying the target phrase. In each condition, lists of 60 phrases (75 dB SPL at ear) were presented concurrently from either two or three audio channels. The phrases recorded by only one of the male talkers were used. The participant was required to respond only to those beginning with a pre-assigned call sign (the target phrases - 25% probability of occurrence within list) by encoding the channel over which the target phrase was presented, the call sign, the colour and the number on the laptop keyboard.

Experiment 2 (Abel et al., 2013)

Participants engaged in two equally important, tasks. For the primary task they were presented 60 pairs of dichotic phrases, this time with simultaneous onsets (70 dB SPL at-ea) over the headset, and responded only to those beginning with a pre-assigned call sign, as in Experiment 1 (27% probability of occurrence across ears). Recordings of two different male talkers were used for the right and left ears, respectively. For the secondary task participants
were required to agree or disagree with arithmetic equations which occurred randomly during presentation of the phrases. The equations were presented on non target trials either over the array of loudspeakers surrounding the head (audio modality, 70 dB SPL at-ear), as a text message on the laptop monitor (visual modality), in both the audio and visual modalities, simultaneously, or not at all (control condition). The tasks were performed in quiet or in a continuous background of 65 dBA at-ear vehicle noise.

RESULTS AND DISCUSSION

Experiment 1

The sound attenuation provided by the communication headset was derived by measuring levels at the entrance to the ear canals of an acoustic test fixture, without and with the headset worn, for each of the vehicle noise and babble noise. Average values increased from 10 dB at 0.125 kHz to 41 dB at 4 kHz and were within 8 dB of the manufacturer’s specifications. The results showed that participants scored close to 100% when responding to phrases presented diotically or dichotically over their headsets, in quiet or noise or over the loudspeakers in quiet. The vision cue was significant in interaction with the other independent variables for diotic listening, and the babble noise for dichotic listening (see Tables 1 and 2). For both listening conditions, the percentage correct was significantly less for phrases presented over the loudspeakers in the vehicle noise by as much as 35%. In diotic listening, the vision cue improved the outcome in the vehicle noise by 7%. In dichotic listening, the presence of babble noise decreased the outcome in the vehicle noise by 12%. A comparison of the at-ear spectra of the speech and noise indicated that the level of the speech from the loudspeaker was below that of the noise from 0.25 to 8 kHz.(see Fig 1).

<table>
<thead>
<tr>
<th>Channel</th>
<th>No Vehicle Noise</th>
<th>Vehicle Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Vision</td>
<td>Vision</td>
</tr>
<tr>
<td>Loudspeaker</td>
<td>98.9 (3.5)*</td>
<td>97.1 (4.0)</td>
</tr>
<tr>
<td>Headset</td>
<td>98.7 (1.7)</td>
<td>99.3 (1.8)</td>
</tr>
</tbody>
</table>

Mean (SD), N=16

<table>
<thead>
<tr>
<th>Channel</th>
<th>No Vehicle Noise</th>
<th>Vehicle Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Babble</td>
<td>Babble</td>
</tr>
<tr>
<td>Loudspeaker</td>
<td>98.7 (1.7)*</td>
<td>94.4 (8.2)</td>
</tr>
<tr>
<td>Lt Headphone</td>
<td>99.0 (2.0)</td>
<td>96.5 (6.1)</td>
</tr>
<tr>
<td>Rt Headphone</td>
<td>99.4 (1.8)</td>
<td>98.1 (2.1)</td>
</tr>
</tbody>
</table>

Mean (SD), N=16
Experiment 2

The second experiment showed again that participants had no difficulty understanding and responding to phrases presented over the communications headset, achieving scores of at least 84%. Lower accuracy relative to the outcome for Experiment 1 was likely due to simultaneous compared with concurrent presentation of dichotic phrases to right and left ears. In agreement with published findings, the left ear showed a disadvantage of 7%, which was mainly due to the choice of call sign. Phrases beginning with one of the call signs resulted in a 12% disadvantage for the left ear compared with a 3% disadvantage for phrases beginning with the other call sign. As shown in Table 3, participants performed significantly better by 18% in quiet and 26% in the vehicle noise on the secondary task when the equations were presented either visually or audio-visually. This outcome is in line with previous findings that listeners are more accurate when messages are delivered over Chat than a standard radio in situations of auditory overload (Finomore et al., 2010). None of the modes of presentation of the secondary task interfered with the primary task.

<table>
<thead>
<tr>
<th>Mode</th>
<th>No Vehicle Noise</th>
<th>Vehicle Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio</td>
<td>80.3 (11.3)</td>
<td>70.7 (14.7)</td>
</tr>
<tr>
<td>Visual</td>
<td>98.4 ( 2.8)</td>
<td>96.1 ( 7.3)</td>
</tr>
<tr>
<td>Audio-visual</td>
<td>98.7 ( 3.3)</td>
<td>96.4 ( 4.3)</td>
</tr>
</tbody>
</table>

Mean (SD), N=19

CONCLUSIONS

Difficulty in understanding speech in noise from surrounding talkers when integrated communication headsets are worn can be explained by at-ear speech-to-noise ratios that favour the noise. Understanding can be aided by visual cues that direct attention to the source and also by simultaneous text messaging. Neither of these options appear to interfere with the understanding of messages presented over the headset, suggesting that texting is a viable
option for communication in cases of degraded audio. A right ear advantage was noted for dichotic messages, supporting previous findings.

ACKNOWLEDGMENTS

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REFERENCES