Spatial Auditory Displays For Use Within Attack Rotary Wing Aircraft

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ABSTRACT
Spatial auditory displays were designed, flown, and evaluated using the Simulation Training Research Advanced Testbed for Aviation (STRATA), a AH-64a Apache simulator, located at the Army Research Institute (ARI) at Fort Rucker, AL. Five trained AH-64 crews (10 subjects) averaging approximately 2200 hours in the airframe, flew a series of night mission scenarios. Spatial auditory displays were provided to both the pilot and the Co-Pilot Gunner (CPG). Both the pilot and the CPG received the same auditory stimuli, but were independently headtracked to provide unique spatial cues for each listener. The evaluation incorporated a within-subjects design. Half the trials used traditional visual displays and the other half used a combination of both visual and spatial auditory displays.

Spatial auditory threat, navigation, and targeting displays were generated and produced using a Silicon Graphics Indigo 2 and spatialized using a Tucker-Davis Technologies PD1 auditory convolver, CX1 expander, and nonindividualized Head Related Transfer Functions (HRTF). Subjects were free to adjust the intensity of the auditory displays to their own comfort levels. All sound stimuli, including ambient helicopter noise, were presented through the pilot's and CPG's headsets which were balanced prior to the start of the evaluation. Ambient helicopter noise was presented at 77 dBA SPL and corresponded to the normal noise experienced by the aircrew while wearing double hearing protection in the actual aircraft. A simple pretest was given to each subject to confirm that they could appropriately localize the auditory stimuli. To evaluate the effectiveness of 3-D audio on cockpit performance, three separate tasks were designed and incorporated into the mission scenarios, representing threat, navigation, and targeting. At the conclusion of the experiment, all subjects completed a brief questionnaire to evaluate their attitudes towards the individual auditory displays and perception of overall system effectiveness.

Due to the small N (five crews) available for the study, only individual data are considered. Statistical power was expectedly low. However, most crews found performance benefits associated with both the threat and targeting displays. In questionnaires, most subjects (67%) were very enthusiastic about incorporating 3-D audio in the radar warning systems. In verbal comments, subjects felt that the use of 3-D audio in the tactical displays would reduce fratricide and that the spatialized warnings were both appropriate and useful. Both the CPGs and Pilots evaluated the navigation stimulus as moderately effective, but found the stimulus itself to be annoying and distracting from the task. In verbal comments, the subjects reported that the stimulus was distracting and an interference to normal cockpit communication. Given the contradiction between reported effectiveness and annoyance, it can be concluded that the attitudes were not related to the usefulness of an auditory navigation beacon, rather to an inadequately designed navigation beacon. This would indicate the need to improve methods for developing these types of displays.

Overall, subjects stated a preference for 3-D verbal displays over 3-D nonverbal displays. Subjects also suggested incorporating spatialized sound into the normal warning displays to give salient cues concerning engine failure. Finally, even though radio communications were not evaluated in the present study, several participants advocated having radio and cockpit communications spatialized.

Keywords
spatial audio, cockpit displays, 3D audio, auditory displays, tactical displays, rotary wing aircraft