IDENTIFYING COGNITIVE CAPABILITIES REQUIRED FOR OPTIMAL EXPLORATION EVA PERFORMANCE: A COGNITIVE TASK ANALYSIS

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BACKGROUND

Extravehicular activity (EVA) is one of the most dangerous and cognitively demanding actions that astronauts can execute, and the cognitive demands associated with future exploration EVA on the Moon and Mars are expected to be higher compared to EVA currently conducted from the International Space Station (ISS). Decrements in cognitive performance present an important risk to crew safety during exploration mission class EVA. Yet there is currently insufficient characterization of the cognitive capabilities required prior to, during, and following EVA. Furthermore, it is unclear which cognitive domains are most important for conducting mission critical decisions with crew safety implications. To address this gap, we conducted a cognitive task analysis of exploration EVA to characterize the cognitive capabilities, critical safety decisions, and contributing factors (e.g., lunar communications delay) important to monitor for optimal performance in future exploration EVA. This cognitive task analysis was conducted through interviews with astronauts and subject matter experts in EVA research and operations. Interviews focused on exploration EVA and elicited feedback on the cognitive capabilities required for specific EVA tasks and subtasks. The information from this cognitive task analysis will help close the gap in our understanding of the key cognitive capabilities required for safe decision-making during exploration mission class EVA on the Moon and Mars.

METHOD

We used an applied cognitive task analysis method[1] over the course of interviews with a total of 15 NASA astronauts and subject matter experts in EVA. Each interview was led by a scientist with expertise in cognitive neuroscience from the Behavioral Health & Performance (BHP) Laboratory at NASA Johnson Space Center. Notes were taken by a research coordinator in the BHP Laboratory and interviews were recorded on Microsoft Teams to ensure the accuracy of notetaking. In the first interview protocol, participants were asked about the specific tasks and cognitive demands associated with EVA. This provided a high-level overview of the steps involved in the major tasks conducted during exploration EVA, as well as which of the steps require the most cognitive skill. Next, participants completed a knowledge audit, which employs a set of probes designed to describe types of domain knowledge of skill and elicit appropriate examples. In the second interview protocol, completed with a separate set of subject matter experts, interviewees were asked to complete a simulated incapacitated crew rescue (ICR) scenario[2], which provided specific context that allowed probing around relevant issues such as situational awareness and potential errors. Experts were then asked to identify the knowledge, skills, and abilities (KSAs) underlying each EVA task and to provide ratings on the importance and cognitive demand of each KSA. Finally, participants also described the most likely and consequential critical safety incidents related to decrements in cognitive performance during exploration EVA and assessed the impact of lunar communication delay on cognitive performance.

RESULTS & DISCUSSION

Interviews for this cognitive task analysis are nearly complete and results will be presented in full at IWS 2025. Results will include a summary of all expert ratings of EVA tasks and subtasks, qualitative summaries of content from each interview part, and a discussion of future directions for products addressing cognitive performance monitoring and cognitive domain mapping in exploration EVA.

ACKNOWLEDGEMENTS

This project was funded by the Mars Campaign Office (MCO), part of NASA's Exploration Systems Development Mission Directorate (ESDMD). KBR authors were supported by KBR's Human Health and Performance Contract NNJ15HK11B with NASA.

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