RESULTS FROM FIRST LABORATORY TESTING OF VIRTUAL ASSISTANT DAPHNE-AT

P.K. Josan[1], P. Dutta[2], R. Abbott[2], A. Viros[2], K. York[2], B.J. Dunbar[2], R.K.W. Wong[3], D. Selva[2], A. Diaz-Artiles[4]

[1,2,4] Department of Aerospace Engineering, Texas A&M University, College Station TX 77843

[3]Department of Statistics, Texas A&M University, College Station TX 77843

[1]poonam.josan@tamu.edu, [4]adartiles@tamu.edu

ABSTRACT

With the continuous advancements in space-rated technologies, long duration exploration missions will become an essential part of the nation's human spaceflight program. The increasing distance between the Earth and mission destinations will cause delayed communications, resulting in delayed response during emergencies. Hence, the success of such missions will rely on reducing Earth dependency. Crew autonomy will play a crucial role in establishing safe and efficient operations when the Earth-based mission support is not readily available. In order to understand this challenge better, a virtual assistant, Daphne-AT, has been designed to assist the crew in detection, diagnosis, and treatment of in-flight anomalies [1, 2]. We are currently conducting several studies with Daphne-AT both in our laboratory and in a flight analog. This abstract describes the experimental design as well as the results from the first laboratory experiment with the first (i.e., baseline) version of Daphne-AT.

A Human-in-the-loop experiment was conducted in a laboratory environment at Texas A&M University. A total of 12 subjects (mean age ± SD = 24.8 ± 1.9 years) were chosen from an astronaut-like population (STEM background). Subjects were presented with time-sensitive Environmental Control and Life Support Systems (ECLSS) anomalies. The anomalies used for the experiment (e.g. CDRA failure) were designed around the interactive habitat systems currently available inside NASA's Human Exploration Research Analog (HERA) habitat, and were simulated using NASA's Habitat Simulation System. These anomalies had varying levels of complexity (measured in terms of time required to resolve the anomaly), and were distributed within-subjects. Additionally, in order to simulate the crew interaction with the HERA hardware, subjects used a virtual 3D model of the HERA habitat systems, and followed the same anomaly treatment procedures as used in HERA [3]. During the experiment, each subject participated in two sessions (one with Daphne-AT and one without), and they were asked to resolve five anomalies in each session. The impact of using Daphne-AT on crewmembers' cognitive workload, situational awareness, and trust in autonomy was measured using NASA Task Load index (TLX), Situational Awareness Rating Technique (SART), and Jian's Trust Scale post-experiment surveys, respectively. Crew performance was characterized by the number of anomalies resolved successfully, and time taken to resolve these anomalies.

Results support the hypothesis that crew performance measures improve with the use of Daphne-AT. The number of anomalies correctly identified, diagnosed, and resolved were 4.1 ± 0.3 (mean ± SE) anomalies with Daphne-AT, and 2.7 ± 0.4 anomalies without Daphne-AT ($p = 0.002$). The situational awareness of the subjects during sessions with Daphne-AT (5.19 ± 0.56) was marginally higher ($p = 0.052$) compared to the sessions without Daphne-AT (4.41 ± 0.71). The cognitive workload also reduced significantly ($p = 0.002$) during the session with Daphne-AT (45.53 ± 6.67) as compared to the sessions when Daphne-AT was not provided (65.97 ± 4.81). Additionally, the data collected from Jian's trust scale indicates that >70% of subjects considered Daphne-AT reliable and trustworthy. These findings and evidence suggest that Daphne-AT will be a valuable crew assistance tool during autonomous human space operations, especially during the tasks that are time-sensitive and critical for crew and mission safety. This research effort is supported by the NASA Human Research Program, Grant number 80NSSC19K0656.

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