Effects of Information Modality and Confidence on Trust and Situation Awareness in Human-Robot Teaming

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Project Overview. Agent transparency in human-machine teams affords human team members the ability to understand the machine's status, reasoning, and future states (Chen et al., 2018). When humans work with an agent that is transparent, they will have an accurate mental model of that machine's behavior and be able to plan and execute their own actions accordingly. The words a robot uses (Guznov et al., 2020) and the modality a robot communicates with (Ezenyilimba et al., n.d.; Fernandes et al., 2018) have been shown to affect human teammates' perceptions of trust and situation awareness (SA), as well as workload and performance. Additionally, agent confidence, a component of transparency, has been shown to improve trust in robot teammates (Wang et al., 2016).

Graphical modalities have been championed as the primary method of communicating agent transparency (Selkowitz et al., 2017), however, in some scenarios, text-based communication has been shown to benefit ratings of trust in robot teammates, and SA, compared to graphical communication (Ezenyilimba et al., n.d.). In this study two methods of conveying agent transparency to a human teammate are examined: text displays and graphical displays. How the presence or absence of agent confidence within each of these displays affects trust, SA, workload, and performance is investigated.

Methods. Sixty-six participants were recruited from Arizona State University and affiliated social media. Participants were randomly assigned to one of three information modality conditions (between-subjects). Participants completed two 20-minute missions, one with confidence information and one without (within-subjects). During each mission, participants teamed up with a highly autonomous search and rescue robot with the goal of navigating a disaster-struck hotel to locate survivors, evaluate the extent of their injuries, and assign medical resources based on their needs. The robot teammate was controlled using a wizard-of-oz technique (Riek, 2012). When the robot reached a survivor, participants were asked to verbally allot one of three limited medical resources depending on the severity of the victim's injuries, using recommendations from the robot and information from the environment. Recommendations were displayed in three different ways depending on the condition: graphical representation, text representation, or both (referred to as the "full" condition). Additionally, depending on the condition, this information may have also included confidence information which represented "how confident the robot was in its recommended medical resource," as explained to participants during training.

Trust in the robot teammate was measured using the Chancey et al., (2017) trust scale and the "Trust Perception Scale-HRI" (TPS-HRI) developed by Schaefer, (2016). SA was measured using the 3D Situation Awareness Rating Technique (Taylor, 1990). Participant performance was measured using the average decision-making time and a performance score that considered the number of victims saved, number of victims given incorrect medical attention, number of victims not found, and mission time.

Results and Discussion. Teams that received graphical information (either the graphics or full conditions) had significantly faster response times and significantly greater performance scores compared to participants that received only textual information. Information modality did not affect trust or SA. As measured by the TPS-HRI trust scale (Schaefer, 2017) and consistent with findings by (Wang et al, 2016), participants reported greater trust when their robot communicated its confidence in a recommendation compared to when the robot did not. According to the interaction effect, this finding is most prevalent in the text condition.

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