Evaluating Team Dynamics for Collaborative Communication Alignment Tasks

Adam Jones

Nia S. Peters

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Adam Jones, Nia S. Peters*
University of Cincinnati, Cincinnati, Ohio
711th HPW, Battlespace Acoustic Branch, Air Force Research Laboratory, Dayton, Ohio*

The primary focus of this work is in exploring human teaming dynamics within goal-oriented communication alignments tasks. A communication alignment task within the context of this work is one in which two teammates have the exact same target information, but from differing perspectives and must communicate in an effort to align their knowledge and agree on the target output. Such an interaction within aviation could occur between a pilot and air traffic controller or ground troop personnel and Unmanned Aerial Vehicle (UAV) controller. The goal is to compare the task performance and time of completion of a communication alignment task between various team compositions: novice-novice, novice-expert, and expert-expert teams. In this work a novice team member is defined as one who is new to the experimental subject panel and has no experience with the simulated communication alignment task at the onset of the data collection. An expert on the other hand has over 6 months of experience on the experimental subject panel and was trained on the task 9 months prior. It is hypothesized that there is a positive correlation between the number of experts within the team composition and the task performance and a negative correlation between the number of experts and the time of completion. The results indicate a decline in task performance and increase in task completion time with less experts on a team. This work aims to better inform the impact that teammate expertise could contribute to performance outcomes within goal-oriented collaborative knowledge alignment interactions.

Effective communication within a team setting is vital and serves as an essential backbone in tasks that require collaboration. In a world where communication is moving rapidly towards electronic mediums, it is important to understand the dynamics that produce the most effective method of communication to maximize the efficiency and performance on collaborative tasks. One such dynamic is that of expertise. This dynamic is important for communication in the domain of aviation, particularly for pilots and air traffic controllers where proper collaborative alignment of information over electronic mediums is imperative and room for error is low. Whereas previous research has focused on the effect of expertise and communication on the individual, this paper serves to better inform team composition in the future by analyzing the importance of expertise level in individuals of a team using accuracy and average time of completion of the task as markers of performance.

Background

In regards to the study of expertise, much of the current literature is focused on the performance on experts and novices outside of a team setting. However, in a recent study it was shown that novices experience collaborative inhibition when working

collaboratively on a task, and experts experience collaborative inhibition when working on a simple task they have previously completed alone (Nokes-Malach, Meade, & Morrow, 2012). This implies that successful collaboration depends on both prior knowledge and experience. It has been shown that experts in a task outperform novices by both quantitative measure of skill and qualitative measure of communication method in normal task settings (Adelson, 1984). Communication methods used by experts have been shown to rely on abstract representations (Hinds, Patterson, Pfeffer, 2001) and greater precision in their descriptions (Solomon, 1990). It was also shown that experts better perform in collaborative tasks when receiving information from other experts as opposed to novices (Solomon, 1990). More recently, experts were shown to give more attention to relevant task information than novices (Sheridan & Reingold, 2014). With these trends in mind, it is the interest of this paper to analyze the effect of expertise level of a team composition on performance on collaborative communication alignment tasks.

Method

A communication alignment task is simulated via a teaming endeavor in which two teammates are tasked with identifying a target from two different perspectives. Within the context of this task, randomly selected team compositions are evaluated based on: 1) team performance, and 2) average task time of completion (TOC). This work explores the composition of expert and novice team compositions. An *expert teammate* is one who has over 6 months of experience on the designated subject panel and was trained on the task 9 months prior. A *novice teammate* is new to the designated subject panel and has no experience with the simulated communication alignment task at the onset of the data collection. The overall assumption is that teams with more experts will outperform teams with less expertise within a collaborative task not only because of task knowledge, but also potential rapport with other subjects that have done the same task. This is a loose assumption because task knowledge does not always guarantee useful teaming collaboration. Other factors such as personality, communication skills, individual performance on the task are all factors that can influence performance outcomes. In this work, the primary focus is on evaluating task performance as a function of teaming composition.

Research Question I: Is there a difference in the team performance of a communication alignment task for different teaming compositions?

H01: There is no difference in the team performance of a communication alignment task for different teaming compositions

H1: There is a difference in the team performance of a communication alignment task for different teaming compositions

Research Question II: Is there a difference in the average time of task completion for a communication alignment task for different teaming compositions?

H01: There is no difference in the average time of task completion for a communication alignment task for different teaming compositions

H1: There is a difference in the average time of task completion for a communication alignment task for different teaming compositions

Data

The goal of the data collection is to simulate a communication alignment task in which two teammates of varying expertise are tasked with identifying a target from two different perspectives. The experimental design presented in this paper is called the Uncertainty Map Task (UMT) which is a variation of the experiment described in (Griffin et al. 2016). In the UMT, two teammates communicate over a push-to-talk network to describe their respective interfaces, ground their knowledge, and identify a target house. A succession of UMT tasks are presented to the team until the team has received 10 randomly generated target house identification tasks. In the UMT task there are 4 aerial maps and 12 houses for each aerial map (12 x 4 = 48 target houses). Each target house has 4 different perspectives. Figure 1 is an example of Graphical User Interface for one of those perspectives, StreetView_Target_Aerial_ID task where the teammate with the street view describes the target house from the street view perspective and the other teammate is tasked with identifying the target house on the aerial map. Whether a teammate receives the target perspective or the identification perspective is also randomly determined in the experiment. When the teammates agree they have identified the correct
house, they press a DONE button and receive feedback on whether they correctly identified the house.

Figure 1: Street View Target and Aerial Identification Task. Teammate I must describe the streetview of the target house (top) and Teammate II must identify the house on the aerial map (bottom)

There are a total of 24 participants in the data collection, 12 experts and 12 novice. There are a total of 126 randomly generated team combinations: expert-expert, expert-novice, and novice-novice with 42 samples per class. The expert-novice and expert-expert have larger sample sizes, but were randomly downsampled because the class size was skewed due to scheduling and availability of subject panel members.

Results

A one-way analysis of variance (ANOVA) was conducted to evaluate the relationship between team composition and team performance. The independent variable, team composition included three levels: expert-expert, expert-novice, and novice-novice. The dependent variable was the percentage correct of identified houses. The ANOVA was significant at the 0.05 level, $F(2,123) = 4.2$, $p = 0.0173$.

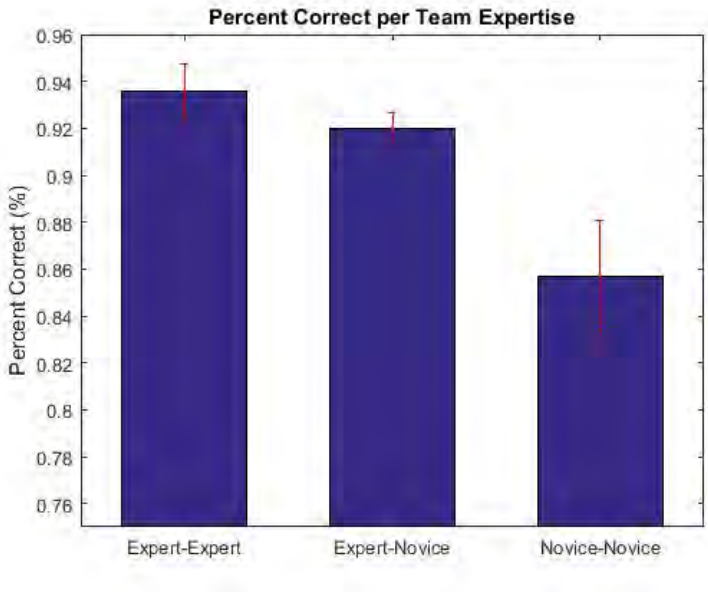

Figure 2: Percent Correct per Team Expertise

Figure 2 illustrates the mean percentage correct for each team composition. These results indicate that there is a significant difference between the means of different team composition illustrating less novice teammates results in degraded teaming performance. These results suggest that we can reject the H01 null hypothesis.

A one-way analysis of variance (ANOVA) was conducted to evaluate the relationship between team composition and average time completion. The independent variable, team composition included: expert-expert, expert-novice, and novice-novice. The dependent variable was the average time of completion to complete a target house identification task (measured in seconds). The ANOVA was significant at the 0.05 level, $F(2,123) = 19.01$, $p = 3.48e08$.

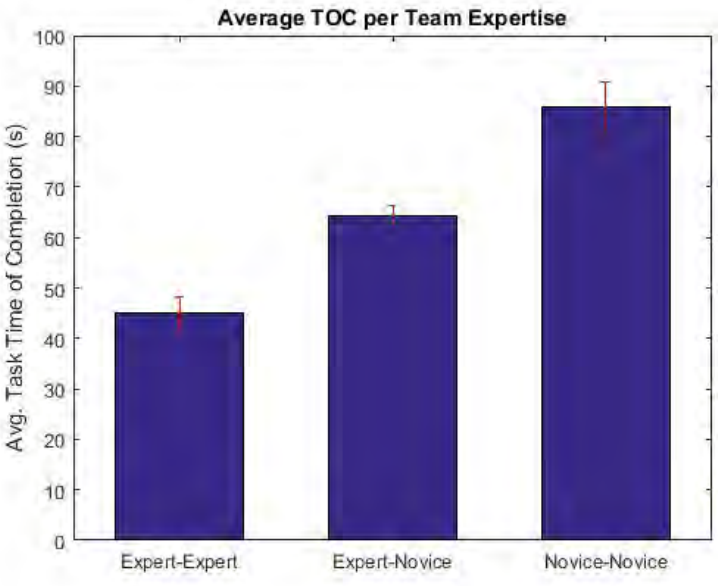

Figure 3: Average Task Time of Completion per Team Expertise

Figure 3 illustrates the mean average time of task completion in seconds for each team composition. These results indicate that there is a significant difference between average time taken to complete a collaborative communication knowledge alignment task for different team composition. teams with more experts complete the task quicker. These results suggest that we can reject the H02 null hypothesis.

Conclusion

The primary focus of evaluating task performance as a function of teaming composition was accomplished through the rejection of both the H01 and H02 null hypotheses, providing evidence that both team performance and average trial completion time of a task are affected by the expertise level of that team composition. Expert-expert teams were found to both perform the highest and have the lowest average trial completion time and novice-novice teams were found to have perfom the poorest and have the highest average trial completion time. This corroborates results found in (Solomon, 1990) from a collaborative communication alignment task. The novice-expert composition performed better and had a lower average trial completion time than the novice-novice team, implying that a novice's performance overall improves when paired with an expert as opposed to a novice. This information can be used in the future to better inform team composition in terms of expertise to produce the best overall performance

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