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14. ABSTRACT
This research tests the efficacy of instructions to increase collaboration and coordination among crew members of a UAV ground-control station. The performance of this research depended upon the development of a UAV synthetic task environment (BRUTE) which was accomplished by upgrading a research tool developed by AFRL. This effort resulted in development of a theoretical perspective of coordination and collaboration in teams as well as a general framework for understanding team interaction and performance in dynamic task environments. The research found limited effectiveness of coordination and collaboration instructions on synthetic crew performance or member situation awareness. The research fou that spatial orientation predicted performance of the AVO and SO functions in a UAV, while no effect of personality factors was uncovered. This research effort also led to a conceptual advance in the prediction of unitary team performance from member individual difference scores. A novel finding from this research was that both independent and interdependent self-construal increased as a function of engaging in a series of missions as members of UAV operator teams.

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Team performance, coordination, collaboration, UAV, air crews

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Enhancing Coordination and Collaboration in Unmanned Air Vehicle (UAV) Crews

Brief Final Report

The Air Force has developed and deployed Unmanned Air Vehicles (UAVs; e.g., the Predator) in a number of locations in the recent past (e.g., Afghanistan, Bosnia, Kosovo). These UAVs are aircraft operated and controlled by a crew in a ground-control station generally out of sight of the vehicle. UAV ground-control station crews are relatively new to the Air Force and raise new issues for the training of personnel. Most UAV training focuses on developing the skills of the individual members so they can perform specific tasks and fulfill their unique responsibilities. However, effective crew performance also relies heavily on the ways the members interact when operating a UAV. Without training in how to work together as a crew, UAV operators must develop strategies on their own, often in a haphazard, intuitive fashion.

Many Air Force crews, such as UAV operators, perform their tasks in rapidly changing environments. Inherent in crew performance of dynamic, complex tasks is an increase in the interdependence of the crew members (in terms of goals, actions, outcomes, interactions, and rewards). Coordination and collaboration become more important for effective crew performance as tasks become more interdependent, complex, and dynamic, and as the interactions among crew members are longer in duration, have greater intensity, and occur more frequently. UAVs clearly involve these complex task and interaction situations. This research addresses the USAF Scientific Advisory Board's recommendations for further research on coordination and collaboration, modeling of crew performance, and task interdependence for the effective use of UAV technologies.

One objective of this research project is to improve the performance of Air Force reconnaissance unmanned air vehicle (UAV) crews by developing guidelines for coordination and collaboration among the crew members. The use of coordination strategies and collaboration skills among UAV crew members should make it possible to leapfrog the time it takes for a crew to become effective and approach optimal levels of performance. These improvements should enhance the effectiveness and integrity of UAV crews as they perform complex tasks in rapidly changing environments with high levels of interdependence. These coordination and collaboration guidelines may also benefit UAV crews as they are asked to take on more complicated duties and responsibilities. This expansion of responsibilities and duties will require even greater coordination and collaboration on the part of UAV crews.

An experiment was conducted to investigate interventions in a UAV synthetic task environment that influence coordination and collaboration, and consequently crew performance and effectiveness. Pairs of participants were given specific instructions on how to interact to achieve coordination and collaboration. It was predicted that coordination (who does what, when, and how) would directly influence crew performance outcomes. Collaboration was predicted to have more substantial influence on the effectiveness of the crew and its integrity over time. Because coordination is more task focused, it was expected to have greater impact on task performance outcomes. Collaboration is viewed as involving effective relations among the crew members and is expected to influence measures of effectiveness separate from task performance. Consequently, this research tested critical aspects of crew performance in UAVs: coordination and collaboration in operator efforts, interdependence in actions and outcomes, and the modeling of crew performance.

Coordination and collaboration are effective ways of responding to the interdependence requirements that are the hallmarks of performance in dynamic crew task environments (Park & Hinsz, 2004). As part of the modeling aspect of this project, a conceptual framework was developed (Hinsz, 2005) for crew performance in complex and dynamic task environments. In addition, a series of models were developed that illustrate the activities and performance of crew members in a UAV ground-control station. These models of crew performance and the conceptual framework are used as a foundation to improve coordination and collaboration among UAV crew members.

Based on this conceptual framework, a theoretical perspective on collaboration and coordination in dynamic crew performance was developed (Park, Hinsz, & Ladbury, 2006). This theoretical approach reflected the ways that collaboration and coordination could be instilled in interacting teams. Moreover, this approach described the similarities and differences between coordination and collaboration in team performance. The experiment conducted then included a 2 (coordination instructions or not) X 2 (collaboration instructions or not) between subjects design. Teams given one of the four types of instructions completed three missions after receiving individual and team training about performing the UAV task. One primary dependent variable was the performance on a UAV mission in a synthetic task environment (BRUTE; Hinsz, 2005). Based on the number of violations committed and targets correctly identified within the time given to complete the mission, a measure of performance was constructed (other performance measures can be constructed that include other elements). A second dependent variable of interest was performance on a knowledge quiz that assessed situation awareness for the mission just completed. Preliminary analyses indicate that the coordination and collaboration instructions did not influence the performance score of the teams or the situational awareness of the team members. However, the situation awareness quiz scores of the members did predict the performance score which is consistent with the literature on situation awareness.

Another objective of this research was to determine if specific individual differences measures might be capable of predicting performance on the UAV task. Because of the interest of AFRL researchers in personality factors, a measure of the five-factors of personality was included in a pretest. Consistent with other research on personality influences, we did not find any influence of personality on team performance scores (Serdiouk & Hinsz, 2006). The lack of an effect of personality factors is reasonable for performance on this task because the situation has such as strong influence on the behavioral requirements of task performance. The personality factors had limited opportunity to influence behavior in such a ‘strong’ situation.

An alternative view of performance on the UAV task is to see it resulting from the spatial orientation abilities of the team members. Spatial orientation is a cognitive ability relating to an individual’s capability to visualize and adapt to changes in spatial location and direction. Given the routing and movement of the UAV aircraft, spatial orientation might be important for the pilots’ efforts to operate the UAV. Similarly, the need of the sensor operator to get camera shots from different angles and directions suggests that spatial orientation may be relevant for successful performance of the sensor operator’s tasks. We included the Purdue Rotation Orientation Test and Card Rotation Test from the Princeton Kit of Cognitive factors. These two measures correlated well with each other and did predict performance of the participants during the training mission.

An important issue that this research project addresses is how to conceptualize the prediction of a unitary team performance score from the levels of individual differences measures (e.g., cognitive abilities) of team members. We proposed a method of conceptualizing and testing the prediction of individual differences on team performance (Ladbury, Hinsz, & Park, 2007). The results of this analysis demonstrate that spatial orientation measures predicted team performance. In particular, the sensor operators' spatial orientation score was a better predictor of team performance, while the pilot's spatial orientation score was a less consistent predictor of team performance. Interestingly, the spatial orientation scores of the pilot and sensor operator did not interact in the prediction of team performance. These results demonstrate a general approach for representing the prediction of team performance from individual differences of the team members.

Another dispositional measure assessed in this research was the self-construal individuals had for themselves. The ways people construe themselves can be divided into two components: independent self-construal and interdependent self-construal. We predicted that as a function of the coordination and collaboration instructions, our participants would become more interdependent in their views of themselves after performing the three missions when they engaged in more coordination and collaboration. While the results did demonstrate that interdependent self-construal increased after performing the missions, we also found that independent self-construal increased after the missions. That is, the experimental setting and procedures led our participants to see themselves as more a member of the team but also as more of an individual performing a specific role in the team (i.e., pilot or sensor operator). This is a unique finding in the self-construal literature that reflects the role that team interaction can have on members' self-perceptions (Ladbury, Hinsz, & Park, 2006).

To accomplish this research, a synthetic task environment needed to be constructed that reflected the operations of UAV pilot and sensor operators in the ground control station. A synthetic task environment was available that had been developed by AFRL. However, the software was out of date and did not function with modern computers. Consequently, a portion of the grant period was spent updating and upgrading the software (BRUTE) so that it would operate in a Windows XP environment. Fortunately, it was possible to make these changes to the program. This turned out to be an important accomplishment because a variety of researchers have asked for copies of this software after it was demonstrated at a UAV conference (Hinsz, 2005).

The Air Force has developed and deployed Unmanned Air Vehicles (UAVs; e.g., the Predator) in a number of locations in the recent past (e.g., Afghanistan, Bosnia, Kosovo). These UAVs are aircraft operated and controlled by a crew in a ground-control station generally out of sight of the vehicle. UAV ground-control station crews are relatively new to the Air Force and raise new issues for the training of personnel. Most UAV training focuses on developing the skills of the individual members so they can perform specific tasks and fulfill their unique responsibilities. However, effective crew performance also relies heavily on the ways the members interact when operating a UAV. Without training in how to work together as a crew, UAV operators must develop strategies on their own, often in a haphazard, intuitive fashion.

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This brief report highlights a number of findings and activities associated with the research project. The research demonstrated how coordination and collaboration can influence team effectiveness and performance in simulated UAV crews. Moreover, this research showed how individual difference variables can be combined from team members to predict a single measure of team performance while identifying individual differences that do and do not affect team interaction and performance in the UAV task environment. This research has motivated other research projects concerned with team interaction and performance in UAV synthetic task environments. Consequently, this research effort will continue to be fruitful.

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