White Paper

Design and Evaluation of a Networked Team Performance Task (N-TPT)

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INTRODUCTION

This white paper submitted to the AFOSR proposes to develop and evaluate a three-person Networked Team Performance Task (N-TPT) that requires cooperation, coordination, sensory-motor skill, visual processing, memory for complex patterns, and leader-follower relationships. As an innovative diagnostic indicator of individual and team performance effectiveness, it is proposed to develop and evaluate a network centric implementation of a blocks-world pattern matching task that has been used extensively to investigate working memory and deictic strategies by individuals (Ballard et al., 1997; Gray et al., 2004) and to assess factors related to memory intensive and interactive intensive problem solutions predicted by an Ideal Performer Model (Gray et al., 2006).

The objective of the N-TPT is to capitalize on blocks world features that may be integrated into a team task that will yield multi-dimensional indices of both individual and team performances that are sensitive to such factors as crew cohesion, stress and fatigue, multi-tasking demands, and mission readiness. The N-TPT will require leadership, decision making, and coordinated sensory-motor movements, all undertaken within the context of challenges to short-term memory and temporal constraints related to accurate pattern matching and movements as a team attempts to model a target pattern with collective and coordinated contributions across successive trials to accomplish that objective. Finally, the implementation of the N-TPT will provide the occasion for consideration of the impact of awareness displays (Dabbish & Kraut, 2008) as such feedback may contribute to optimizing movement and the selection of resources in the reproduction of a target model configuration by the team.

BACKGROUND

Where the successful accomplishment of an organization's mission requires the coordinated contributions of two or more individuals collectively identified with the achievement of a common objective, the conditions for a team are operationally defined (Emurian et al., 1984). This definition is consistent with Salas et al. (2007) who emphasize teams to be units of people having (1) task interdependencies and dynamic social interactions, (2) shared valued goals, (3) a limited lifespan, (4) distributed expertise, (5) and clearly defined participant roles. Eliciting and evaluating teamwork within distributed multiplayer game-based settings have been acknowledged to show great potential for engaging players in immersive and simulated environments in which to observe complex behaviors having direct relevance to the mission of an organization, to include the U.S. military (Hussain et al., 2008) and the National Aeronautics and Space Administration (Emurian et al., 2009; Hienz et al., 2008). Related research documents the applications of online computer games to support collaborative and distributive communications, peer interactions, and resource sharing to achieve learning objectives (Papastergiou, 2008), and guidelines for the development of collaborative educational videogames overlap with several of the five features of a team given above (Zea et al., 2009). Finally, Mayo (2009) noted that an attractive dimension of game-based assessment is its potential to track sequences of user actions and communications that can be mapped onto higher-order skills and abilities.

Although the range of settings to which such definitions and game-based scenarios might be applied is obviously broad and encompassing (Salas et al., 2007), identifying a common conceptual framework is anticipated to facilitate the ongoing study of factors related to team performance effectiveness (Salas et al., 2008). In that regard, Hess et al. (2005) addressed some of the challenges associated with bringing critical aspects of operational team performance within the scope of laboratory-based analyses, and the N-TPT to be described within this white paper falls within the recommended tactic of abstracting functional properties of teams that may lend themselves to empirical study within the context of controlled experiments. The proposed evaluations will show how a multiplayer and distributed computer game may be designed and deployed to assess the operational status and cohesiveness of a three-person team under varying conditions of workload. The approach taken addresses several research questions posed by Letsky and Warner (2008) with particular emphasis upon the development of metrics to assess inter-member collaborative performance within teams. The background of this work also includes recent analyses of three-person teams undertaking collaborative decision making within the context of optimizing pattern matching scenarios for monetary rewards (Hayne et al., 2005).

The nature and complexity of future network centric warfare systems based upon distributed and networked teams are problematic issues that involve important strategic and technological considerations. Under such circumstances, specific operational readiness assessment requirements and training regimens are difficult to determine, and the imperatives involved in configuring effective behavioral systems management in support of individuals and crews are best served by the expeditious development of methodological approaches that are heuristic and innovative. Despite uncertainties associated with the cognitive performance requirements of such network centric environments, many are likely to be highly dispersed with extensive capabilities for interdependent actions. A primary focus of conceptual and methodological research advances, then, must be upon the development of technological and behavioral systems management of the human cognitive, social, and skilled performance repertoires to be optimized and sustained under such challenging conditions of interoperability. The N-TPT is in furtherance of such an objective.

TECHNICAL N-TPT CONSIDERATIONS

The attached figure presents a diagrammatic representation of one operator’s console across successive views from the display of a model to the team members’ deposits of resources during a single completed trial with the task. In brief, as shown in the **General Layout**, the objective is for a three-person team to reproduce the pattern in the **Model** in the initially empty **Workspace** by moving blocks from the **Resource Tray** to the **Workspace**.

The **First View** shows an operator’s display at the beginning of a trial. Both the Model and the Workspace are dim.

The **Second View** shows the visible Model after the user has moved the cursor into the space. When the user moves the cursor into the dim Model, the pattern becomes visible for a fixed time period (e.g., 2 sec), after which the Model again becomes dim. Repeated displays of the Model require moving the cursor outside the Model space and back into the Model space.

The **Third View** shows the red block in the Resource Tray highlighted by the user's activation of the mouse button over that resource. The fact that the red resource block has been selected indicates that the team members have been directed by a previously designated or team-selected leader regarding the resource block color that each team member is to engage for a particular movement.

The **Fourth View** represents coordinated movements (i.e., blocks being dragged) from the Resource Tray into the Workspace. Initiation of all three movements must occur within a fixed time interval (e.g., 0.5 sec). This requires the leader to issue a command to coordinate the movements of the resource blocks. Failure to coordinate aborts the trial, and the task display is reset to the First View for all team members.

The **Fifth View** shows a successful movement coordination initiation and the subsequent display of the Workspace after all three resource blocks have entered it. Prior to this move, it was required that the team members, perhaps being directed by the leader or by consensual discussion, decide how a particular movement trial into the Workspace will contribute to matching the pattern in the Model. In the example, there are nine different colored blocks in the Model and in the Resource Tray, but the colors within the Model might be identical or might vary along different dimensions. The complexity of the Model also lends itself to variation, increasing or decreasing the cognitive load of the task on memory and decision making.

The **Sixth View** shows the Workspace after all three resource blocks have been accurately deposited. If any block has been deposited inaccurately, the trial is aborted, and the task display is reset to the First View for all team members.

Engagement with the task continues until the Model is successful reproduced within the Workspace. The N-TPT, then, requires vigilance to scan a visual stimulus, short-term memory for a pattern, cooperation in the designation of aspects of a pattern to be matched, coordinated movements, agreement to follow the commands of a leader, effective motor movements, and sustained attention.

At each phase of the task, objective metrics of individual and team performance effectiveness are available for observation and analysis. At the global team level is the total time required for a team to reproduce a Model in the Workspace. Other metrics include the following: (1) the number of displays of the Model by an individual team member before selecting a block from the Resource Tray, (2) the number of accurate and inaccurate selections of a resource block, (3) the number of effective and ineffective coordinated movements, and (4) the number of accurate and inaccurate deposits into the Workspace

Task Challenges and Research Scenarios. The design of the N-TPT provides the opportunity to manipulate cognitive workload by modifying the size and complexity of the model to the matched. Although the prototype will be a 5x5 grid, the optimal size is a matter for exploration under controlled laboratory conditions. The pattern under consideration also lends itself to the requirement that realistic images be processed and corresponding mappings reproduced or tagged.

Other modifications relate to challenges within the team itself. For example, in the face of deteriorating performance by a team member, it may be requested by that member that the display duration of the Model be increased or that the interval for coordinated movements be increased. Such a change might require all team members to engage in an ancillary task that imposes a degree of "cost" associated with any change in the task parameters. Related challenges include a "missing man" scenario to determine how long it takes a team to identify that a member is missing and to undertake corrective countermeasures to complete a mission. Team membership challenges may be extended to a scenario where one designated "multi-tasking" member must participate as a common member within two simultaneously operating teams.

Additional challenges to performance effectiveness on this task include the introduction of distracters to one or more team members between the offset of the Model and the availability of the Workspace. For example, a distracter icon might be displayed at an unpredictable screen location and require the user to select it before the Workspace becomes available. A distracter might be programmed for all team members or for only one member such that the team must decide who engages the distracter. Finally, the sensitivity of the N-TPT warrants evaluation under conditions of fatigue and sleep deprivation.

The N-TPT will be implemented as an internet based tool, similar to our foundational Team Performance Task (TPT) (Emurian et al., in review). As such, it lends itself to performance assessment when team members are within the same space and can openly communicate with each other and when team members are geographically disbursed, communicating electronically. Although the initial N-TPT design and assessment will focus upon a three-person team, the task scenario is readily extendable to larger teams.

EVALUATION PROTOCOL

Support is sought to implement and evaluate the N-TPT. In addition to the indices of individual and team performance indicated above, the NASA-TLX and a test of group cohesion (Salisbury et al., 2006) will be administered during research protocols with the task.

We propose to evaluate this task and associated scenario modifications by recruiting volunteers from the UMBC student community to participate in a series of 1-2 hr sessions. This is consistent with our previous work with the foundational TPT. Task parameters will be chosen such that evaluations of the N-TPT will produce results that contribute to the developing science of distributed and face-to-face network centric team performance effectiveness. The N-TPT will reflect the technology of behavioral systems management (Emurian et al., 2009) as applied to human cognitive, social, and skilled performance repertoires, optimized and sustained under face-to-face and distributed networked conditions.

DELIVERABLES

The programmatic developments of the N-TPT will be made available to the AFOSR. In that regard, it is anticipated that evaluations of this task will include on-site studies in collaboration with our sponsor. Finally, the outcomes of laboratory studies at UMBC will be disseminated to the scientific community through recognized venues for publications and conference presentations.

We would appreciate the opportunity to discuss submitting a formal proposal to the AFOSR to undertake this work.

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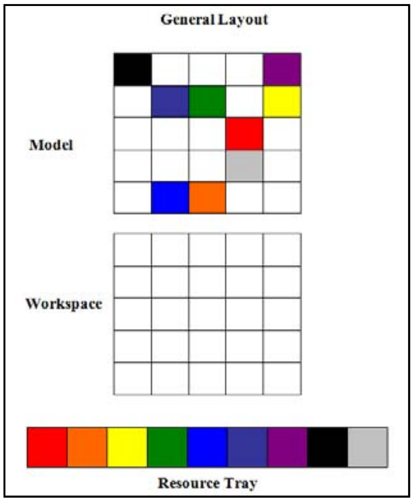
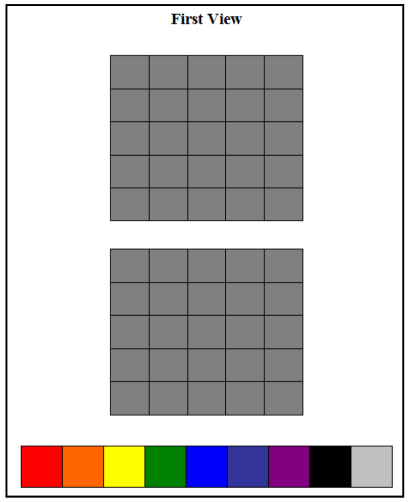
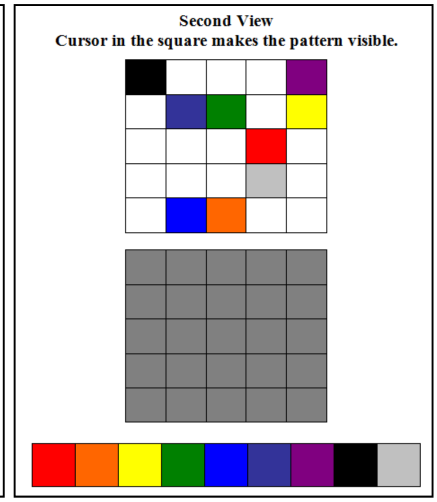
Networked Team Performance Task (N-TPT)







Presented here is the General Layout of one operator's console. The six views show the display as one operator engages the task from illuminating the model pattern (Second View) to three correct deposits in the Workspace by all three team members (Sixth View).