

Access to this work was provided by the University of Maryland, Baltimore County (UMBC) ScholarWorks@UMBC digital repository on the Maryland Shared Open Access (MD-SOAR) platform.

Please provide feedback

Please support the ScholarWorks@UMBC repository by emailing scholarworks-group@umbc.edu and telling us what having access to this work means to you and why it's important to you. Thank you.

This chapter appears in M.M. Cruz-Cunha, V.H. Carvalho, & P. Tavares (Editors), Business, Technological, and Social Dimensions of Computer Games: Multidisciplinary Developments (Chapter 13). Copyright 2011, IGI Global. Posted by permission of the publisher.

www.igi-global.com

Business, Technological, and Social Dimensions of Computer Games: Multidisciplinary Developments

Maria Manuela Cruz-Cunha
Polytechnic Institute of Cávado and Ave, Portugal

Vitor Hugo Costa Carvalho
Polytechnic Institute of Cávado and Ave, Portugal

Paula Cristina Almeida Tavares
Polytechnic Institute of Cávado and Ave, Portugal

Senior Editorial Director:	Kristin Klinger
Director of Book Publications:	Julia Mosemann
Editorial Director:	Lindsay Johnston
Acquisitions Editor:	Erika Carter
Production Editor:	Sean Woznicki
Typesetters:	Keith Glazewski, Natalie Pronio, Jennifer Romanchak, Milan Vracarich Jr.
Print Coordinator:	Jamie Snavelly
Cover Design:	Nick Newcomer

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: <http://www.igi-global.com>

Copyright © 2011 by IGI Global. All rights reserved. No part of this publication may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher. Product or company names used in this set are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI Global of the trademark or registered trademark.

Library of Congress Cataloging-in-Publication Data

Business, technological, and social dimensions of computer games:
multidisciplinary developments / Maria Manuela Cruz-Cunha, Vitor Hugo Carvalho
and Paula Tavares, editors.

p. cm.

Includes bibliographical references and index.

Summary: "This book is a collection of the most recent developments in all areas of game development, encompassing planning, design, marketing, business management, and consumer behavior"--Provided by publisher.

ISBN 978-1-60960-567-4 (hbk.) -- ISBN 978-1-60960-568-1 (ebook) 1. Video games industry. 2. Video games--Design. 3. Video games--Social aspects. I. Cruz-Cunha, Maria Manuela, 1964- II. Carvalho, Vitor Hugo, 1979- III. Tavares, Paula, 1973-

HD9993.E452B87 2011

338.4'77978--dc22

2011012885

British Cataloguing in Publication Data

A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter 13

A Multiplayer Team Performance Task: Design and Evaluation

Henry H. Emurian
UMBC, USA

Eric D. Gasior
Institutes for Behavior Resources, USA

Gerald C. Canfield
UMBC, USA

Robert D. Hienz
Johns Hopkins University School of Medicine, USA

Peter G. Roma
Institutes for Behavior Resources, USA

Steven R. Hursh
Johns Hopkins University School of Medicine, USA

Zabecca S. Brinson
Institutes for Behavior Resources, USA

Joseph V. Brady
Johns Hopkins University School of Medicine, USA

ABSTRACT

This chapter describes a Team Performance Task (TPT) that has been designed to assess the status of a three-person team operating a game-like multiplayer task requiring inter-player cooperation to achieve optimal performance effectiveness. The objective of the TPT is to extract features of an operational setting that may be integrated into a task scenario that will yield multi-dimensional indices of both individual and team performances that are sensitive to alterations in the workload parameters and to the skill level and cohesion of the players. The design of a prototype task is described in detail, and evaluative results based on observations of five groups of three players are presented to show the individual and team metrics of performance effectiveness that are made available with this task. Future applications of the TPT are suggested, to include its potential to diagnose and support the cohesiveness and operational readiness of teams operating within space-based and other challenging environments.

INTRODUCTION

The Team Performance Task (TPT) presented within this chapter operationalizes teamwork

processes that relate to both team performance and group cohesion (LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). Its conceptualization is consistent with a classic definition of a computer

DOI: 10.4018/978-1-60960-567-4.ch013

game (Crawford, 1982): “A [computer] game is a closed formal system that subjectively represents a subset of reality.” The task to be described shows how such a conceptualization and formal definition were applied to capture significant aspects of the operational status of a team. The task is deployed on the Internet, but its design intentionally did not require consideration of usability problems typically found in multiplayer features associated with network computer games (Pinelle, Wong, Stach, & Gutwin, 2009). The present work is directed primarily to assessing the status of space-dwelling crews in response to NASA’s continuing emphasis on the development of tools to monitor crewmember and crew-ground interactions¹, although the design and validation of a task that can diagnose the status of a team could have wide applicability in both basic research and applied settings.

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, Brady, Ray, Meyerhoff, & Mougey, 1984). This definition is consistent with Salas, Rosen, Burke, Nicholson, and Howse (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, Weil, Brunye, Sidman, Alexander, & Ferguson, 2008) and the National Aeronautics and Space Administration (Emurian,

Canfield, Roma, Gasior, Brinson, Hienz, Hursh, & Brady, 2009; Hienz, Brady, Hursh, Gasior, Spence, & Emurian, 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, Sanchez, Gutierrez, Cabrera, & Paderewski, 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, Stagl, Burke, & Goodwin, 2007), identifying a common conceptual framework is anticipated to facilitate the ongoing study of factors related to team performance effectiveness (Salas, Cooke, & Rosen, 2008). In that regard, Hess, MacMillan, Serfaty, and Elliot (2005) addressed some of the challenges associated with bringing critical aspects of operational team performance within the scope of laboratory-based analyses, and the TPT and evaluative research presented in this chapter fall within the recommended tactic of abstracting functional properties of teams that may lend themselves to empirical study within the context of controlled experiments. The research 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, Smith, & Vijayasarathy, 2005).

Team cohesion has been identified as a proxy for all levels of team functioning (van Vianen & De Dreu, 2001), to include social cohesion and task cohesion. Although it is acknowledged that research supports a relationship between team cohesion and performance (Kozlowski & Ilgen, 2006), conceptualizing and assessing team cohesion and relating it to team performance continue to challenge researchers in this area of work (Beal, Cohen, Burke, & McLendon, 2003). The range of issues addressed is indicated by studies of team cohesion undertaken by administering self-report questionnaires to individual team members in recent research addressing such issues as computer mediated communications (Stone & Posey, 2008), the personality of team members (MacDonnell, O'Neill, Kline, & Hambley, 2009; van Vianen & De Dreu, 2001), collective efficacy within engineering student project teams (Lent, Schmidt, & Schmidt, 2006), and enterprise resource planning implementation success (Wang, Ying, Jiang, & Klein, 2006). The range of behavioral, cognitive, and motivational approaches to assessing teamwork also challenges researchers in this area of investigative analysis (Shanahan, Best, Finch, & Sutton, 2007). Against that background, the present work provides an occasion to relate individual member's perception of team cohesion to objective measures of individual and team performance.

Although the approach to be described generally follows the definition of a team by Salas et al. (2007), the particular task to be described and evaluated provides the opportunity for team members to have similar roles and responsibilities in the achievement of a performance outcome. Such an orientation differs from a consideration of team processes that emphasize individual team members having different roles and responsibilities (Humphrey, Morgeson, & Mannor, 2009; Kozlowski & Ilgen, 2006). It will be seen, however, that the task does require team mem-

ber interdependence as conceptualized by Chen, Tan, and Wang (2009), in that individual team members had to rely on the support provided by other members to achieve optimal performance outcomes. Finally, the task was designed to provide objective measures of individual and team performance while minimizing the requirements for extensive training and skill development, factors that have been the focus of considerable research and that are obviously important to consider within related contexts (Aguinis & Kraiger, 2009; Salas & Cannon-Bowers, 2001).

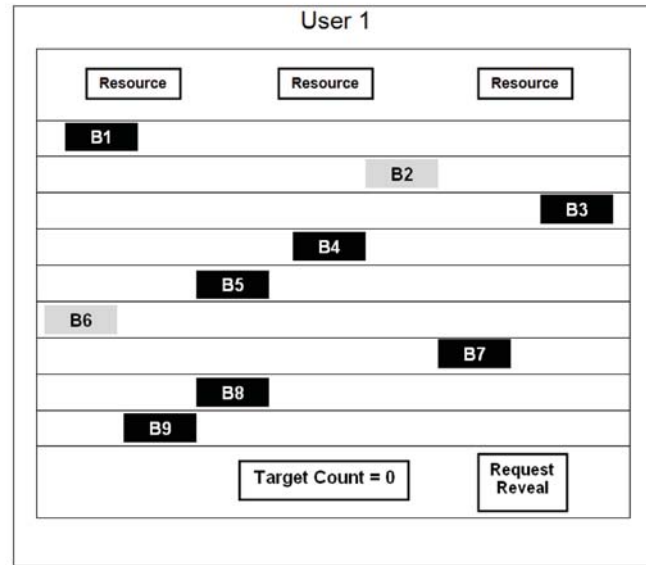
TEAM PERFORMANCE TASK (TPT)

Design: Description of the TPT

The TPT prototype described herein was designed for use by three-person groups. Figure 1 presents a diagrammatic representation of the display presented to a participating group member (in this case, User 1). The display is similar for all three team participants, who operate the task from three separate computer terminals. In the current configuration, communications are not permitted among the three players beyond task-related actions and feedback. The server for the TPT, which is deployed on the Internet, was running on a port behind the UMBC firewall.

Below the member designation label are three **Resource** blocks. Each block is a different color. At the bottom center of the display is a block labeled **Target Count = 0**. For a trial, the target block at the bottom will be the same color as one of the three resource blocks at the top. In brief, the task requires a player to drag and deposit on the target the resource block that matches the color of the target block. The resource block must be dragged to the target block while avoiding barriers positioned within the nine rows between the resource blocks and the target. One barrier is positioned within each of the nine rows, and the barriers move horizontally in a row at random

Figure 1. A diagrammatic representation of the display presented to User 1



times varying between 10 and 20 seconds. When a barrier is repositioned, it can appear anywhere in the row, to the right or to the left of its original position. For a correct deposit on the target, which involves moving and depositing an identically colored resource block without striking a barrier, one point is added to the Target Count. If a barrier is struck, however, one point is subtracted from the Target Count, which can become negative. A resource block is allowed to overlap approximately 20% of a barrier without generating a barrier hit. Any overlap greater than that constitutes a barrier “hit” and causes the Target Count to be reduced by one point. Whenever a barrier hit occurs, the associated resource block is eliminated from further play, and a new resource block at the top has to be dragged to the target.

In the display presented to the subjects, the three resource blocks were 1.25 by 2.5 cm, the barriers were 0.5 by 2 cm, and the target block was 1.25 by 3 cm. Each row in the display was 1 cm high and 21 cm long. When a dragged resource block occludes at least 40% of the target block, a border appears around the target block indicating

that the resource block may be successfully deposited by releasing the mouse button, assuming that the colors match. If the wrong colored resource block is deposited, one point is subtracted from the target count. The three resource blocks are colored yellow, red, and light blue.

Three barriers are assigned to each player, and the three rows associated with a player’s set of three barriers are determined randomly at the beginning of a session. Each player controls the visibility of those three barriers to the two other players. When a barrier is first displayed, either at the beginning of a session or whenever a barrier is repositioned, that barrier is visible only on the controlling player’s display. For example, the two barriers labeled B2 and B6 in Figure 1 are “dim” (gray) and only visible to User 1. A player’s barrier is made visible to the other players by an action requiring holding the cursor over the barrier with the left mouse key depressed for a fixed time period. The barrier then becomes black and can be seen by all players. Optimal individual performance, then, requires cooperation among the three players to illuminate their respective

barriers so that resource block movements by other team members can avoid hitting barriers, thereby permitting individual target counts to be maximized.

At the bottom right of the display is a button labeled “Request Reveal.” When a player clicks that button with the mouse, a text message is presented at the top of the displays of the other two teammates. For example, if User 1 clicks that button, the following message appears to the other two players: “User 1 has requested that you reveal your barriers.” Successive messages appear in a scrollable list, and all messages on a player’s display are removed whenever that player initiates movement of a resource block.

In summary, the TPT consists of three basic behaviors all aimed at facilitating point accumulation, but directed towards either the player him/herself (dragging blocks from Resource to Target and barrier reveal requests) or his/her teammates (revealing one’s own barriers). It is important to note that these active behaviors are all mediated by a standard single cursor/mouse configuration, and are thus mutually exclusive; for example, one cannot attempt to score points via block drags while simultaneously revealing barriers. It is this inherent conflict between maximizing individual performance and facilitating others’ performances within the time constraints of the task that defines the TPT conceptually, and how individuals and groups allocate the resource of time within an objective, quantifiable, and relatively rapid task that makes the TPT an innovative and promising behavioral assay.

Evaluation: Observations of Performance Effectiveness

This section presents the results of research showing performance on this multiplayer task under conditions of varying workload demands created by altering the barrier reveal delay duration from 250 msec to 4000 msec during experimental laboratory evaluations with five three-person teams.

The results will be interpreted within the context of a discussion of the applications of this task to the assessment of the operational readiness of teams to undertake missions requiring member interdependency, cooperation, and skilled performance. These outcomes will show the capability of the TPT to reflect the presence or absence of team members’ dispositions to perform in ways that stabilize workload equivalently among respective players, and as such, the task may have diagnostic utility in assessing group cohesion. The analysis will focus upon general outcomes observed by combining data across the teams, although the results of individual team-member actions will be presented and discussed as needed to document the sensitivity of the range of metrics under consideration in this initial evaluation of the TPT.

Fifteen volunteer participants were recruited from the UMBC community of students. Announcements were made in Information Systems classes and circulated on student listservs. Potential subjects were told that they would each receive \$20 for completing the study, which required approximately one hour. The study was approved by UMBC’s Institutional Review Board, and written informed consent was obtained at the time of participation. Table 1 presents information about the subjects, which was obtained immediately prior to the study. Two rating scales were administered to assess each subject’s experience with computer games and overall computer experience (Emurian, Holden, & Abarbanel, 2008). Each scale was a 10-point scale, where the anchors were *1 = No Experience (I am a novice.)* to *10 = Extensive Experience (I am an expert.)*. As can be seen in Table 1, there were seven male and eight female participants, and the mean age was 20 years (range = 19 to 22). Twelve of the subjects were undergraduate majors in a computer-related discipline. The mean reported game experience was 6.5 (range = 3 to 10), and the mean reported overall computer experience was 8.1 (range = 7 to 10). Subjects within Group 3 (G3) and Group 5 (G5) were unacquainted prior to the study, whereas

all other subjects within respective groups knew one another. Subjects within G1 were male, and subjects within G2 and G4 were female. In both G3 and G5, there were two males and one female. No attempt was made to control the composition of the teams during this initial evaluation of the TPT, and the composition of the groups was determined by the availability of subjects as they volunteered successively for the study.

The research took place within a small, rectangular, windowless laboratory containing four tables, with each table holding a PC and with two PCs positioned several feet apart along the two lengthwise walls. The subjects were seated such that they did not face each other. The task was presented to each subject on a Dell Optiplex 745 PC having a 17-inch screen. One or two research assistants managed the study and remained within the laboratory with the subjects. The subjects were instructed not to speak to each other during the study, and the only direct method of

communication permitted was through requests to reveal barriers, a feature of the task.

The procedure for all groups was as follows. Subjects first introduced themselves to each other, followed by completing the demographic questionnaires. Next, the task was described using figures of the display, and informed consent was obtained. The subjects were informed that the purpose of this study was to learn about the ways that members of a team perform when they all were instructed to maximize their individual point accumulations. The orientation to the task was similar to the “no specific goal condition” that was one of four individual and group goal conditions studied by Mitchell and Silver (1990). This was followed by a 4-min training session in which the barrier reveal delay duration was 1000 msec, such that to reveal a barrier to teammates, each subject was required to press and hold the left mouse button for 1000 msec while the cursor was within a dim barrier. At the end of that inter-

Table 1. Subjects Who Participated in the TPT Evaluations

Team	Player	Status	Major	Sex	Age	Game Experience	Computer Experience
G1	1	Sophomore	Chemical Engineering	M	19	7	10
	2	Senior	Information Systems	M	21	8	9
	3	Junior	Biology	M	21	10	7
G2	1	Sophomore	Information Systems	F	19	4	7
	2	Sophomore	Computer Engineering	F	19	3	7
	3	Junior	Computer Science	F	20	10	8
G3	1	Junior	Information Systems	M	22	6	8
	2	Sophomore	Health Administration & Policy	F	19	5	8
	3	Junior	Information Systems	M	22	8	8
G4	1	Junior	Information Systems	F	19	6	8
	2	Sophomore	Computer Science	F	19	5	8
	3	Sophomore	Information Systems	F	20	8	8
G5	1	Senior	Information Systems	F	20	4	9
	2	Junior	Information Systems	M	20	7	9
	3	Junior	Information Systems	M	20	9	8
				53% F	Mean = 20	Mean = 6.5	Mean = 8.1

val, the barrier changed from dim to illuminated (gray to black on Figure 1), and the barrier was then visible to all three team participants. Subjects were informed that the duration of the barrier reveal delay might be different across sessions, but they were not informed about the parameters that were presented. There was no feedback on a subject's task display to indicate the length of the barrier reveal delay.

The three subjects performed the task during six successive 6-min sessions during which the following barrier reveal delays were programmed within successive sessions: 250, 500, 1000, 2000, 4000, and 250 msec. After each 6-min session, subjects completed the 6-item Perceived Cohesion Scale (PCS) (Salisbury, Carte, & Chidambaram, 2006), which yielded ratings of group Belonging and Morale, and the NASA Task Load Index² (NASA-TLX), a measure of perceived workload (Cao, Chintamani, Pandya, & Ellis, 2009).

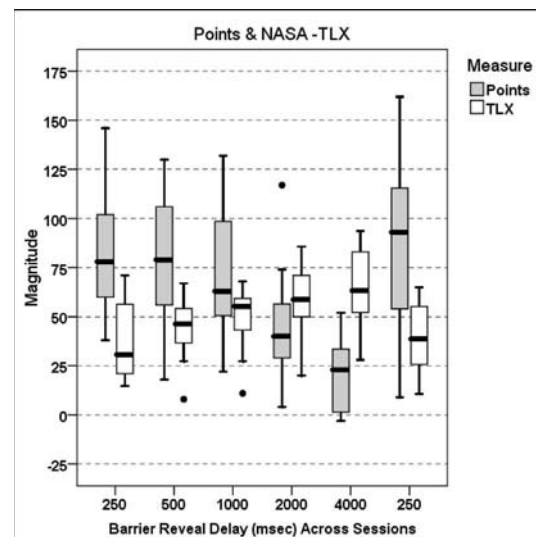
Figure 2 presents boxplots of total points earned by all participants across the six successive sessions. Also presented are the corresponding NASA-TLX outcomes following the completion of each session. The figure shows graphically that points earned generally declined over the first five sessions and increased during the final session in which the barrier reveal delay was returned to 250 msec. The negative point value evident during the 4000 msec session was attributable to the behavior of S3 in G3, who accumulated three barrier hits below a point tally of zero. During that same 4000 msec session, both S1 and S2 in G3 earned zero points. All other participants showed positive point accumulations during all six sessions.

Although the range of points earned was greater during the final session with the 250 msec barrier reveal delay, in comparison to the first session, the higher median value observed during that final session was likely at least partly attributable to improvement in skill on the TPT over successive sessions. In contrast, the NASA-TLX values increased over the first five sessions, followed by a drop during the final session. For

points, a within-subjects contrast for linear trend over the first five successive sessions was significant³ ($F = 64.06, p = .000$). For the NASA-TLX outcomes, a within-subjects contrast for linear trend over the first five successive sessions was also significant ($F = 23.07, p = .000$). The inverse relationship between points earned and the perception of workload is likely attributable to the effort expended by subjects associated with the increases in barrier reveal delays, and these effects will be interpreted below.

Figure 3 presents boxplots of events related to the barriers. Presented on the figure are requests to reveal barriers, actions to reveal barriers, and barrier hits for all participants across the six sessions. The figure shows graphically that subjects made requests for the other teammates to reveal barriers during all sessions, with the lowest number evident graphically during the 4000 msec delay interval. The figure also shows that one or more subjects made no request to reveal barriers across all six sessions. The notably high frequency (96) of

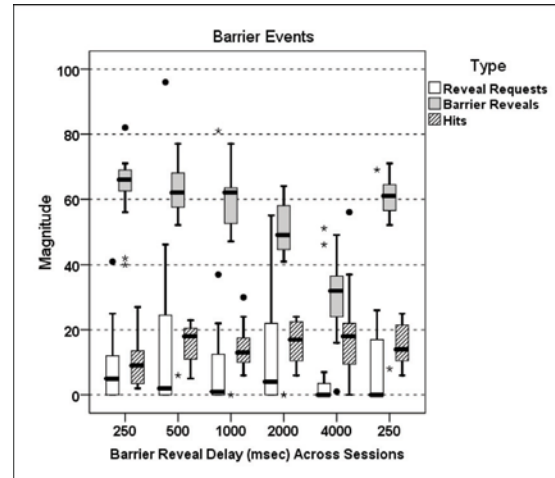
Figure 2. Boxplots of total points earned by all participants across the six successive sessions. Also presented are the corresponding NASA-TLX outcomes following the completion of each session. Filled circles are outliers.



barrier reveal requests evident during the 500 msec delay session was attributable to the actions of S1 in G4. With respect to actions to reveal barriers, the figure shows graphically that the number of reveal actions dropped over the first five sessions with an increase during the final session. For barrier hits, the figure suggests that hits increased modestly overall across the first five sessions, but a notable drop was not apparent during the final session. A within-subjects contrast for linear trend over the first five successive sessions was not significant for requests to reveal barriers ($F = 0.98, p = .340$), significant for actions to reveal barriers ($F = 175.83, p = .000$), and significant for barrier hits ($F = 5.70, p = .032$).

Figure 4 presents ratings on the PCS Belonging and Morale scales for each participant within each group across the six sessions. The figure shows graphically that some members in both groups whose participants were unacquainted prior to the study (i.e., G3 and G5) showed low ratings on both the Belonging and Morale scales, in comparison to ratings observed by members in the other three groups. No obvious gender effect was evident since the low PCS ratings in G3 were by a male (S1) and the low ratings in G5 were by a female (S1). Those ratings were also unrelated to point accumulations as suggested by the within-team homogeneity of point totals for members within G3 and G5 that are evident within Figure 5, to be described. The overall correlation between points earned by each participant within each session and the mean cohesion ratings obtained after each session was significant for the Belonging scale (Spearman's $\rho = .206, p = .052^4$), but not significant for the Morale scale (Spearman's $\rho = .158, p = .137$). No other significant relationship was observed between these PCS ratings and the objective outcomes of performance. These data, then, reflect a modest relationship between interpersonal cohesiveness, as determined by the Belonging ratings, and task cohesiveness (Mullen & Cooper, 1994), the latter determined by task performance, and they are

Figure 3. Boxplots of events related to the barriers. Filled circles are outliers, and the stars are extreme values.



consistent with a suggested directional relationship between task performance and an aggregated measure of team cohesion (Fullagar & Egleston, 2008).

Evaluation: Novel Metrics of Group Cohesion

Although the barrier reveal actions that were evidenced by the participants reflect one metric of team-member cooperation, a more comprehensive measure was obtained, and this metric was designated as the Prosocial Index (PSI). The PSI is the proportion of all TPT actions by a team member that are accounted for by that member's barrier reveal actions. The PSI's constituent actions include attempts to move resource blocks to the target to score points, requests for other players to reveal their barriers, and actions to reveal one's own barriers to the two teammates. As noted above, because these actions are mutually exclusive at any given point in time, the PSI reflects how time is budgeted by each team member over the course of a session into actions that facilitate the opportunity for other team members to score points

Figure 4. Perceived Cohesion Scale ratings on the Belonging and Morale scales for each participant within each group across the six sessions.

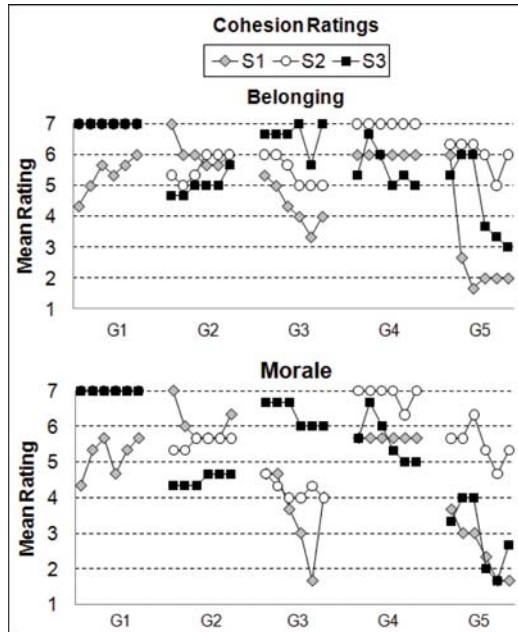
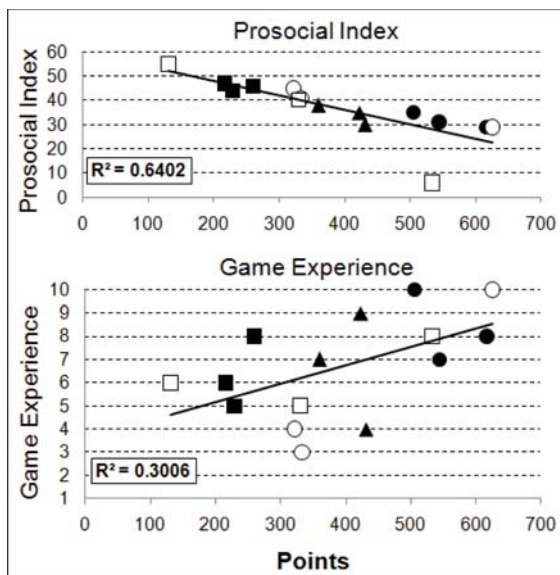


Figure 5. Scatterplots of the Prosocial Index and total points earned (top) and reported game experience and total points earned (bottom). Filled circle = Group 1; Empty circle = Group 2; Filled square = Group 3; Empty square = Group 4; and Filled triangle = Group 5.



(i.e., barrier reveals) contrasted with actions having the objective of increasing a member's own point count (i.e., resource block movements and barrier reveal requests). The PSI, then, is calculated as follows for an individual team member: **[barrier reveal actions / (barrier reveal actions + requests to reveal barriers + resource block movements)] x 100**. Quantitatively, the fact that the PSI is a relative measure (i.e., a proportion) mitigates the influence of individual differences in sensorimotor skill or TPT experience. To illustrate, team members with disparate skill levels may appear differentially cooperative if the raw barrier reveal count was the only metric used to assess prosocial behavior (e.g., 100 barrier reveals vs. 50 barrier reveals in a session). However, those same two participants may also differ in their output of "selfish" behaviors in that same session (i.e., resource block movements and requests to reveal barriers) and may accordingly budget their time similarly with equal willingness to help their teammates avoid hitting invisible barriers (e.g., 100 vs. 50 of the other behaviors, yielding PSIs of 50 for both players).

When applied to the present dataset, Figure 5 presents scatterplots of the PSI and total points earned (top) and reported game experience and total points earned (bottom). The figure is based upon the sum of the outcomes across all six sessions for PSI actions and points. With respect to the PSI, a linear relationship is graphically evident, and the relationship was significant (Spearman's $\rho = -.95, p = .000$). In general, as point accumulations by individual team members increased, corresponding PSI values decreased, as one would expect based on how the PSI is calculated. Notable in this figure is the relative homogeneity of the PSI and total points obtained by members of teams whose members were unacquainted prior to the study (G3 and G5), in comparison to members of the other three teams. The outlier data point visible for the empty square showing high points (533) and a low PSI (6) was generated by S3 in G4. With respect to game experience,

a linear relationship is graphically evident, and the relationship was significant (Spearman's $\rho = .529, p = .042$). The subject showing the lowest reported game experience (3) was S2 in G3. On the PSI scatterplot, that subject is represented by the empty circle data point generated by 333 points and 41 PSI. There was no significant relationship between total points and reported overall computer experience (Spearman's $\rho = .340, p = .215$) or between reported game experience and reported overall computer experience (Spearman's $\rho = .101, p = .719$).

Although the PSI provides a unique insight on group cohesion within the TPT, like other metrics, it is limited in that it only reflects performance at a single point in time or single condition. That is, PSIs may be calculated for individuals and groups at each session or averaged grossly across sessions, but whether measuring the reinforcing value of natural rewards such as food and drink, drugs of abuse such as cocaine and alcohol, or social rewards such as cooperation and reciprocity, a valid method for quantifying behavior change across a range of increasingly demanding conditions has proven elusive. Fortunately, recent advances in behavioral economics have produced the "Exponential Model of Demand" (Hursh & Silberberg, 2008), a highly sensitive and broadly applicable model that is well-suited to TPT data. Following the economic analogy alluded to earlier in this chapter, each player may be considered a "consumer," the amount of time required per barrier reveal within a TPT session is the "price" of cooperation, and all players have a limited "budget" defined by session length. For the present study, whenever a player wished to help his/her teammates, s/he had to pay 250, 500, 1000, 2000, or 4000 msec of time per unit of cooperation (i.e., each barrier reveal), during which time s/he could not work towards individual point accumulation. What makes the model innovative is that rather than quantifying "consumption" at any given price or averaging across prices, it specifically yields a single number characterizing the rate of change

in cooperative responses over the entire range of prices—or "sensitivity to price"—regardless of absolute levels of consumption. In relation to the TPT data presented here, we define price as the time cost of barrier reveals, and while cooperation is generally defined as barrier reveals or PSI, an apparently cooperative individual's willingness to reveal barriers at the "inexpensive" 250 msec requirement may not hold as the barrier reveal requirements grow increasingly costly. The exponential model, then, allows for a more sophisticated definition of group cohesion by quantifying cooperation not as barrier reveals at any given point, but as the sensitivity of this cooperative behavior across the range of time requirements necessary to sustain it.

Although the computational details of the exponential model are beyond the scope of this chapter⁵, the key parameters of interest are Q_0 , which represents predicted consumption at no cost (e.g., baseline barrier reveals if they required no time) and α , which represents sensitivity of consumption across the range of prices. It is important to note that because α represents sensitivity to price, relatively small α values indicate less sensitivity and thus a greater willingness to sustain cooperative behavior at a fixed level. Also note that the model normalizes data to account for baseline individual differences and produce more meaningful α values, but Q_0 is still useful to check for outliers who show very little cooperative behavior but do so consistently across all prices or other outliers whose response patterns otherwise distort model parameters. Since the exponential model assumes decreasing consumption as a function of price, raw barrier reveal data are most appropriate for the TPT. Application of the model to the raw barrier reveal output suggests that the model adequately describes TPT data on multiple levels, with a mean r^2 value for individual demand curves of 0.83 and median of 0.91 (range 0.44-1.00), a mean r^2 value for average barrier reveals within each three-person team of 0.94 and median of 0.95 (range 0.85-0.98), and an overall

r^2 for mean barrier reveals by all 15 participants of 0.98. The left panel of Figure 6 presents characteristic demand curves produced by the model after fitting mean barrier reveal performance for each group as a function of barrier reveal “price” requirement, with the teams composed of familiar (G1, G2, G4) and stranger (G3, G5) participants; the right panels present Q_0 (top) and α (bottom) values for the five group curves generated by the model. Given the cooperative nature of the TPT, one may predict that teams of familiar individuals would (1) emit more barrier reveals and (2) be less sensitive to the cost of cooperation compared to their unfamiliar counterparts. Although more systematic experiments would be required to test these hypotheses, Figure 6 clearly shows the exponential model’s ability to differentiate groups on multiple parameters using objective behavioral data, including a greater resistance to price increases (lower α) in two of the familiar groups in comparison to the two stranger groups. Taken together, these introductory results illustrate the exponential model’s suitability for quantitative analyses at the individual, group, and global levels, and suggest its potential sensitivity to cohesion-relevant group differences within the TPT paradigm.

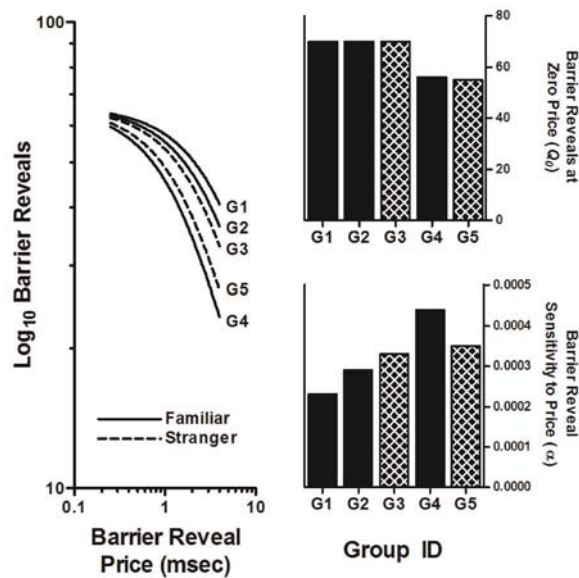
Discussion

This initial evaluation of the TPT validated the task’s potential to assess individual and team performance effectiveness from the perspective of several objective metrics of skill and cooperation: total points, barrier reveals, requests to reveal barriers, and barrier hits. The task showed its sensitivity to detect an individual member’s willingness to cooperate with teammates within the context of a game-like scenario that provided minimal performance feedback and that prevented verbal communications among members of the team, while at the same time necessitating cooperation if all members of a team were to achieve a similar outcome in terms of maximizing individual

point accumulations. The task parameters chosen for this evaluation clearly affected perceptions of workload as revealed by the changes in the NASA-TLX outcomes observed as the barrier reveal delay increased from 250 msec to 4000 msec. Prior familiarity of teammates may have impacted perceptions of group cohesion under conditions of increased workload, with suggestive evidence, however, that high individual point accumulations might obviate such effects.

Members within two of the teams (G3 and G5) were unacquainted prior to the study, and the composition of those teams was mixed gender. Although “swift trust” (Robert, Dennis, & Hung, 2009) apparently emerged almost immediately upon task initiation for all teams, to include G3 and G5, it was notable that the relationship between the PCS Belonging ratings and points earned was apparently driven, at least in part, by the extent of team member familiarity prior to undertaking the study, because there was no evidence of a gender effect. Members within G3 and G5 were unacquainted prior to the study, and some members within both of those groups showed low ratings, unrelated to gender, on Belonging and Morale, especially during sessions with the relatively lengthy barrier reveal delays. Although preliminary, it is promising to note that these subjective estimates of relatively low cohesion in G3 and G5 were echoed in part by the analyses afforded by the exponential model (i.e., greater sensitivity to barrier reveal price versus teams composed of familiar players). Since the TPT was novel for all participants, the influence of shared team mental models, in terms of what the members knew about each other’s skill before and during the study (Johnson & Lee, 2008; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000), was considered to be minimal. Recent simulations, however, have suggested that team performance is correlated with team familiarity (Singh, Dong, & Gero, 2009), although the present task scenario emphasized the accumulation of individual points by the team members even though optimizing

Figure 6. Data derived from application of the Exponential Model of Demand (Hursh & Silberberg, 2008) on TPT mean barrier reveal behavior within five individual teams (G1-G5). The left panel presents characteristic demand curves produced by the model after fitting mean barrier reveal performance for each group as a function of barrier reveal “price” requirement (msec); the right panels present Q_0 (top) and α (bottom) values for the five group curves generated by the model and displayed in the left panel. Teams composed of familiar players are indicated by solid lines and bars whereas teams composed of strangers are indicated by dashed lines and hatched bars



such points required intermember cooperation with respect to revealing barriers. Moreover, the only information about what other team members were doing during the six successive sessions was based upon the requests for members to reveal barriers. In that sense, team situational awareness was minimized (Garbis & Artman, 2004). A particular team member, then, might have inferred from such requests that other team members were suffering point losses by striking barriers and were motivated to increase their point tallies.

Participants in this study were motivated to perform the task by the impact of instructions that each team member should try to accumulate as many individual points as possible during each session. There was no differential compensation based upon point differences among the subjects at the conclusion of the study. There was also

no feedback presented to the subjects regarding their teammates' point accumulations, such that real-time competition among the team members might be considered negligible. Although such a “do your best” tactic is not an uncommon approach (Kozlowski & Ilgen, 2006), alternatives to control motivational factors might be anticipated to improve the capability of the TPT to inspire optimal performance by all team members. In that regard, the highest number of total points (625) was earned by S3 in G2, a female computer science major with Game Experience of 10 and Overall Computer Experience of 8. The lowest number (131) was earned by S1 in G4, a female information systems major with Game Experience of 6 and Overall Computer Experience of 8. Although experience and skill might have played a role in such a range of outcomes, standardiz-

ing motivational factors would be anticipated to uncover the influence of such a factor in a more exacting manner. Even with the interdependences programmed in this task scenario, the objective was an individualized objective, rather than a group-collective objective, and consideration of these factors, together with differential incentives for individual and team outcomes (Bryant, Albring, & Murthy, 2009; Rynes, Gerhart, & Parks, 2005; Willer, 2009), is anticipated to yield valuable insights into the range of TPT applications. As stated by Ilgen and Sheppard (2001), “Motivationally, it is necessary to understand those factors that influence each team member’s willingness to contribute his or her time and effort in such a way that the team performs effectively” (p. 174). Future investigations with the TPT will include consideration of such factors within the framework of an experimental analysis.

Within the psychological literature, prosocial behavior has been conceptualized as helping behavior performed by one individual to benefit another (George, 1991). Although the current task design might occasion such behavior, for all team members to optimize point accumulations required a willingness among members to reveal barriers for reasons that extend beyond altruism. In that regard, the need for reciprocity in revealing barriers is at least somewhat similar to the conditions for direct reciprocity, in which the recipient of a benefit returns a benefit directly to the giver (Molm, Shaefer, & Collett, 2007). Moreover, Wang and Wang (2008) reported that participants in online games may be simultaneously affected by altruism and reciprocity when helping others, without regard to gender. There are, however, many additional factors involved in social exchange decisions, to include temperament, character, and even hormonal status (Wischniewski, Windmann, Juckel, & Brune, 2009). Moreover, the potentially mediating influence of group cohesion on the effects of task interdependency, as they relate together to organizational citizenship behavior, was suggested by Chen et al. (2009). The Prosocial

Index and Exponential Model of Demand explored within the current study, then, may address many of these issues from the perspective of integrative objective metrics, and they are promising tools with which to standardize the status of members of a team without regard to differential outcomes observed among the several metrics of individual and team performance forthcoming from the TPT.

FUTURE RESEARCH DIRECTIONS

The validation of the functional properties of the TPT as observed in the present study lays the foundation for extending this assessment tool in several directions relevant to basic research and applied objectives. With respect to basic research, fundamental issues pertaining to individual and team processes remain to be addressed. Rather than relying on instructions to motivate performance, the impact of explicit monetary rewards for both individual and team performance needs to be investigated as such an approach might standardize motivation (Baker, Jensen, & Murphy, 1988) and overcome the detrimental effects of what has been described as “social loafing” within virtual teams (Bryant et al., 2009).

The current task scenario also lends itself to investigations of incentive effects under conditions of individual as compared to team (i.e., shared) outcomes of performance effectiveness (Thurkow, Bailey, & Stamper, 2000). Other “work design” factors (Grant, Fried, Parker, & Frese, 2010; Grant & Parker, 2009) that warrant further investigation include effects of requiring a designated number of individual or team points that must be completed as a session objective (e.g., Emurian, Canfield, & Brady, 2010). Moreover, extensions of the task design to incorporate analyses of the resilience and impact of designated leader-follower roles (Avolio, Reichard, Hannah, Walumbwa, & Chan, 2009), together with communications, training, and strategy discussion effects (Dalenberg, Vogelaar, & Beersma, 2009), are indicated within future

research directions. In that regard, the applications and further validation of the TPT as an assay of a team's status following extended performance on a three-person planetary exploration simulation mission (Hienz, et al., 2008; Roma, Hursh, Hienz, Emurian, Gasior, Brinson, & Brady, 2011) are currently being undertaken at the Institutes for Behavior Resources. Finally, the importance of investigating the potential applications of the TPT as a technique to improve subsequent prosocial behavior by team members is suggested by recent studies showing that players of computer games, in which game characters help and support each other in nonviolent ways, show an increase in both short-term and long-term prosocial behaviors, defined broadly as behavior intended to help others (e.g., Gentile, Anderson, Yukawa, Ihori, Saleem, Ming, Shibuya, Liau, Khoo, Bushman, Huesmann, & Sakamoto, 2009).

CONCLUSION

The entertainment, engagement, and excitement associated with the synthetic worlds created by gaming and digital-media designers have been merged with such applications as instructional design to improve learning and training outcomes (Cannon-Bowers & Bowers, 2010). Although the present Internet-based system was intentionally designed to be austere with respect to its interface features, its multi-player and game-like functionality captured actions by members of a three-person team to yield metrics of individual and team performance and cooperative behavior. The resulting metrics are promising as indices of the operational status of a team and the readiness and willingness of a group of individuals to engage in interdependent and cooperative behavior in support of a common objective. The importance of designing and validating tools to assess the status of crewmembers residing within the stressful conditions of space-based environments for long-duration missions has been repeatedly

acknowledged (Brady, 2005; Emurian & Brady, 2007). The TPT is promising not only as an assessment tool, but also as a potential behavioral systems countermeasure to foster and manage essential crew cohesion under such conditions and to affirm the authority relationships within the crew and between the crew and mission control (Emurian et al., 2009). Given the design of the task as a rapid and objective behavioral assay of the fundamental elements of group cohesion, a fully developed and well-validated form of the TPT may prove valuable in a variety of basic research and applied operational settings.

ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions of Emily Toy and Oana Tibu, undergraduate students in Information Systems at UMBC, who managed the TPT evaluations and supported the data analysis.

This research was supported in part by the National Space Biomedical Research Institute through NASA NCC 9-58-NBPF01602.

REFERENCES

- Aguinis, H., & Kraiger, K. (2009). Benefits of training and development for individuals and teams, organizations, and society. *Annual Review of Psychology*, 60, 451–474. doi:10.1146/annurev.psych.60.110707.163505
- Avolio, B. J., Reichard, R. J., Hannah, S. T., Walumbwa, F. O., & Chan, A. (2009). A meta-analytic review of leadership impact research: Experimental and quasi-experimental studies. *The Leadership Quarterly*, 20(5), 764–784. doi:10.1016/j.leaqua.2009.06.006

- Baker, G. P., Jensen, M. C., & Murphy, K. J. (1988). Compensation and incentives: Practice vs. theory. *The Journal of Finance*, 43(3), 593–616. doi:10.2307/2328185
- Beal, D. J., Cohen, R. R., Burke, M. J., & McLendon, C. L. (2003). Cohesion and performance in groups: A meta-analytic clarification of construct relations. *The Journal of Applied Psychology*, 88(6), 989–1004. doi:10.1037/0021-9010.88.6.989
- Brady, J. V. (2005). Behavioral health: The propaedeutic requirement. *Aviation, Space, and Environmental Medicine*, 76(6), 13–24.
- Bryant, S. M., Albring, S. M., & Murthy, U. (2009). The effects of reward structure, media richness and gender on virtual teams. *International Journal of Accounting Information Systems*, 10(4), 190–213. doi:10.1016/j.accinf.2009.09.002
- Cannon-Bowers, J. A., & Bowers, C. A. (2010). Synthetic learning environments: On developing a science of simulation, games, and virtual worlds for training. In Kozlowski, S. W. J., & Salas, E. (Eds.), *Learning, Training, and Development in Organizations* (pp. 229–261). New York, NY: Taylor & Francis Group.
- Cao, A., Chintamani, K. K., Pandya, A. K., & Ellis, R. D. (2009). NASA TLX: Software for assessing subjective mental workload. *Behavior Research Methods*, 41(1), 113–117. doi:10.3758/BRM.41.1.113
- Chen, C.-H. V., Tan, Y.-Y., & Wang, S.-J. (2009). Interdependence and organizational citizenship behavior: Exploring the mediating effect of group cohesion in multilevel analysis. *The Journal of Psychology*, 14(6), 625–640. doi:10.1080/00223980903218273
- Crawford, C. (1982). *The Art of Computer Game Design*. Retrieved from <http://www.stanford.edu/class/sts145/Library/Crawford%20on%20Game%20Design.pdf> and <http://www.vancouver.wsu.edu/fac/peabody/game-book/Chapter1.html>
- Dalenberg, S., Vogelaar, A. L. W., & Beersma, B. (2009). The effect of a team strategy discussion on military team performance. *Military Psychology*, 21(Suppl. 2), 31–46. doi:10.1080/08995600903249107
- Emurian, H. H., & Brady, J. V. (2007). Behavioral health management of space-dwelling groups: Safe passage beyond Earth orbit. *Behavior Analyst Today*, 8(2), 25–41. Retrieved from <http://www.baojournal.com/>.
- Emurian, H. H., Brady, J. V., Ray, R. L., Meyerhoff, J. L., & Mougey, E. H. (1984). Experimental analysis of team performance. *Naval Research Reviews*, 36(1), 3–19.
- Emurian, H. H., Canfield, G. C., Roma, P. G., Gasior, E. D., Brinson, Z. S., Hienz, R. D., et al. (2009). Behavioral systems management of confined microsocieties: An agenda for research and applications. In *Proceedings of the 39th International Conference on Environmental Systems* (Paper number: 2009-01-2423), Warrendale, PA: SAE International.
- Emurian, H. H., Canfield, K., & Brady, J. V. (2010). Behavior analysis of team performance: A case study of membership replacement. *Behavior Analyst Today*, 11(3), 161–185. Retrieved from <http://www.baojournal.com/>.
- Emurian, H. H., Holden, H. K., & Abarbanel, R. A. (2008). Managing programmed instruction and collaborative peer tutoring in the classroom: Applications in teaching Java™. *Computers in Human Behavior*, 24(2), 576–614. doi:10.1016/j.chb.2007.02.007

- Fullagar, C. J., & Egleston, D. O. (2008). Norming and performing: Using Microworlds to understand the relationship between team cohesiveness and performance. *Journal of Applied Social Psychology*, 38(10), 2574–2593. doi:10.1111/j.1559-1816.2008.00404.x
- Garbis, C., & Artman, H. (2004). Team situation awareness as communicative practice. In Banbury, S., & Tremblay, S. (Eds.), *A Cognitive Approach to Situation Awareness: Theory and Application* (pp. 275–296). Burlington, VT: Ashgate Publishers.
- Gentile, D. A., Anderson, C. A., Yukawa, S., Ihori, N., Saleem, M., & Ming, L. K. (2009). The effects of prosocial video games on prosocial behaviors: International evidence from correlational, longitudinal, and experimental studies. *Personality and Social Psychology Bulletin*, 35(6), 752–763. doi:10.1177/0146167209333045
- George, J. M. (1991). State or trait: Effects of positive mood on prosocial behaviors at work. *The Journal of Applied Psychology*, 76(2), 299–307. doi:10.1037/0021-9010.76.2.299
- Grant, A. M., Fried, Y., Parker, S. K., & Frese, M. (2010). Putting job design in context: Introduction of the special issue. *Journal of Organizational Behavior*, 31, 145–157. doi:10.1002/job.679
- Grant, A. M., & Parker, S. K. (2009). Re-designing work design theories: The rise of relational and proactive perspectives. *Academy of Management Annals*, 3, 273–331. doi:10.1080/19416520903047327
- Hayne, S. C., Smith, C. A. P., & Vijayasarathy, L. R. (2005). The use of pattern-communication tools and team pattern recognition. *IEEE Transactions on Professional Communication*, 48(4), 377–390. doi:10.1109/TPC.2005.859726
- Hess, S. M., MacMillan, J., Serfaty, D., & Elliot, L. (2005). From cognitive task analysis to simulation: Developing a synthetic team task for AWACS weapons directors. Air Force Research Laboratory, Brooks AFB, TX, 78235. Retrieved from <http://handle.dtic.mil/100.2/ADA440345>
- Hienz, R. D., Brady, J. V., Hursh, S. R., Gasior, E. D., Spence, K. R., & Emurian, H. H. (2008). Effects of incentives on psychosocial performances in simulated space-dwelling groups. *Acta Astronautica*, 63, 800–810. doi:10.1016/j.actaastro.2008.03.003
- Humphrey, S. E., Morgeson, F. P., & Mannor, M. J. (2009). Developing a theory of the strategic core of teams: A role composition model of team performance. *The Journal of Applied Psychology*, 94(1), 48–61. doi:10.1037/a0012997
- Hursh, S. R., & Silberberg, A. (2008). Economic demand and essential value. *Psychological Review*, 115(1), 186–198. doi:10.1037/0033-295X.115.1.186
- Hussain, T. S., Weil, S. A., Brunye, T. T., Sidman, J., Alexander, A. L., & Ferguson, W. (2008). Eliciting and evaluating teamwork within a multiplayer game-based training environment. In O’Neil, H. F., & Perez, R. S. (Eds.), *Computer Games and Team and Individual Learning* (pp. 77–104). Oxford, UK: Elsevier Ltd.
- Ilgen, D. R., & Sheppard, L. (2001). Motivation in work teams. In Erez, M., Kleinbeck, U., & Thierry, H. (Eds.), *Work Motivation in the Context of a Globalizing Economy* (pp. 169–178). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Johnson, T. E., & Lee, Y. (2008). The relationship between shared mental models and task performance in an online team-based learning environment. *Performance Improvement Quarterly*, 21(3), 97–112. doi:10.1002/piq.20033

- Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest*, 7(3), 77–124.
- Lent, R. W., Schmidt, J., & Schmidt, L. (2006). Collective efficacy beliefs in student work teams: Relation to self-efficacy, cohesion, and performance. *Journal of Vocational Behavior*, 68, 73–84. doi:10.1016/j.jvb.2005.04.001
- LePine, J. A., Piccolo, R. F., Jackson, C. L., Mathieu, J. E., & Saul, J. R. (2008). A meta-analysis of teamwork processes: Tests of a multidimensional model and relationships with team effectiveness criteria. *Personnel Psychology*, 61, 273–307. doi:10.1111/j.1744-6570.2008.00114.x
- Letsky, M., & Warner, N. W. (2008). Macrocognition in teams. In Letsky, M. P., Warner, N. W., Fiore, S. M., & Smith, C. A. P. (Eds.), *Macrocognition in Teams: Theories and Methodologies* (pp. 1–13). Burlington, VT: Ashgate Publishing Company.
- MacDonnell, R., O'Neill, T., Kline, T., & Hambley, L. (2009). Bringing group-level personality to the electronic realm: A comparison of face-to-face and electronic contexts. *The Psychologist Manager Journal*, 12, 1–24. doi:10.1080/10887150802371773
- Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *The Journal of Applied Psychology*, 85(2), 273–283. doi:10.1037/0021-9010.85.2.273
- Mayo, M. J. (2009). Video games: A route to large-scale STEM education? *Science*, 323(5910), 79–82. doi:10.1126/science.1166900
- Mitchell, T. R., & Silver, W. S. (1990). Individual and group goals when workers are interdependent: Effects on task strategies and performance. *The Journal of Applied Psychology*, 75(2), 185–193. doi:10.1037/0021-9010.75.2.185
- Molm, L. D., Shaefer, D. R., & Collett, J. L. (2007). The value of reciprocity. *Social Psychology Quarterly*, 70(2), 199–217. doi:10.1177/019027250707000208
- Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological Bulletin*, 115(2), 210–227. doi:10.1037/0033-2909.115.2.210
- Papastergiou, M. (2008). Online computer games as collaborative learning environments: Prospects and challenges for tertiary education. *Journal of Educational Technology Systems*, 37(1), 19–38. doi:10.2190/ET.37.1.c
- Pinelle, D., Wong, N., Stach, T., & Gutwin, C. (2009). Usability heuristics for networked multiplayer games. In *Proceedings of the ACM 2009 International Conference on Supporting Group Work* (pp. 169–178).
- Robert, L. P., Dennis, A. R., & Hung, Y.-T. C. (2009). Individual swift trust and knowledge-based trust in face-to-face and virtual team members. *Journal of Management Information Systems*, 26(2), 241–279. doi:10.2753/MIS0742-1222260210
- Roma, P. G., Hursh, S. R., Hienz, R. D., Emurian, H. H., Gasior, E. D., Brinson, Z. S., & Brady, J. V. (2011). Behavioral and biological effects of autonomous versus scheduled mission management in simulated space-dwelling groups. *Acta Astronautica*, 68, 1581–1588. doi:10.1016/j.actaastro.2009.09.034
- Rynes, S. L., Gerhart, B., & Parks, L. (2005). Personnel psychology: Performance evaluation and pay for performance. *Annual Review of Psychology*, 56, 571–600. doi:10.1146/annurev.psych.56.091103.070254
- Salas, E., & Cannon-Bowers, J. A. (2001). The science of training: A decade of progress. *Annual Review of Psychology*, 52, 471–499. doi:10.1146/annurev.psych.52.1.471

- Salas, E., Cooke, N. J., & Rosen, M. A. (2008). On teams, teamwork, and team performance: Discoveries and developments. *Human Factors*, 50(3), 540–547. doi:10.1518/001872008X288457
- Salas, E., Rosen, M. A., Burke, C. S., Nicholson, D., & Howse, W. R. (2007). Markers for enhancing team cognition in complex environments: The power of team performance diagnosis. *Aviation, Space, and Environmental Medicine*, 78(5). Section, II, B77–B85.
- Salas, E., Stagl, K. C., Burke, C. S., & Goodwin, G. F. (2007). Fostering team effectiveness in organizations: Toward an integrative theoretical framework of team performance. In R.A. Dienstbier, J.W. Shuart, W. Spaulding, & J. Poland (Eds.), *Modeling Complex Systems: Motivation, Cognition and Social Processes, Nebraska Symposium on Motivation*, 51 (pp. 185-243). Lincoln, NE: University of Nebraska Press.
- Salisbury, W. W., Carte, T. A., & Chidambaram, L. (2006). Cohesion in virtual teams: Validating the perceived cohesion scales in a distributed setting. *The Data Base for Advances in Information Systems*, 37(2 & 3), 147–155.
- Shanahan, C., Best, C., Finch, M., & Sutton, C. (2007). Measurement of the behavioural, cognitive and motivational factors underlying team performance. Report Number: DSTO-RR-0328. Australian Government Department of Defence, Air Operations Division. Retrieved from <http://hdl.handle.net/1947/8882>
- Singh, V., Dong, A., & Gero, J. S. (2009). Effects of social learning and team familiarity on team performance. In *Proceedings of the 2009 Spring Simulation Multiconference* (San Diego, California, March 22 - 27, 2009). Spring Simulation Multiconference. Society for Computer Simulation International, San Diego, CA, 1-8.
- Stone, N. J., & Posey, M. (2008). Understanding coordination in computer-mediated versus face-to-face groups. *Computers in Human Behavior*, 24, 827–851. doi:10.1016/j.chb.2007.02.014
- Thurkow, N. M., Bailey, J. S., & Stamper, M. R. (2000). The effects of group and individual monetary incentives on productivity of telephone interviewers. *Journal of Organizational Behavior Management*, 20(3), 3–25. doi:10.1300/J075v20n02_02
- van Vianen, A. E. M., & De Dreu, C. K. W. (2001). Personality in teams: Its relationship to social cohesion, task cohesion, and team performance. *European Journal of Work and Organizational Psychology*, 10(2), 97–120. doi:10.1080/13594320143000573
- Wang, C.-C., & Wang, C.-H. (2008). Helping others in online games: Prosocial behavior in cyberspace. *Cyberpsychology & Behavior*, 11(3), 344–346. doi:10.1089/cpb.2007.0045
- Wang, E. T. G., Ying, T.-C., Jiang, J. J., & Klein, G. (2006). Group cohesion in organizational innovation: An empirical examination of ERP implementation. *Information and Software Technology*, 48, 235–244. doi:10.1016/j.infsof.2005.04.006
- Willer, R. (2009). Groups reward individual sacrifice: The status solution to the collective action problem. *American Sociological Review*, 74(February), 23–43. doi:10.1177/000312240907400102
- Wischniewski, J., Windmann, S., Juckel, G., & Brune, M. (2009). Rules of social exchange: Game theory, individual differences and psychopathology. *Neuroscience and Biobehavioral Reviews*, 33, 305–313. doi:10.1016/j.neubiorev.2008.09.008
- Zea, N. P., Sanchez, J. L. G., Gutierrez, F. L., Cabrera, M. J., & Paderewski, C. P. (2009). Design of educational multiplayer videogames: A vision from collaborative learning. *Advances in Engineering Software*, 40, 1251–1260. doi:10.1016/j.advengsoft.2009.01.023

ENDNOTES

- ¹ http://www.nasa.gov/mission_pages/station/science/experiments/Interactions.html
- ² <http://humansystems.arc.nasa.gov/groups/TLX/>
- ³ Statistical tests were undertaken with SPSS.
- ⁴ For this initial investigation, the null hypothesis of no relationship was rejected based

upon $p = .052$. Although this increases the risk of making a Type I error, we accepted that risk rather than neglect to consider a potentially important relationship in these data. Ultimately, replication of this research will determine the robustness of these observations.

- ⁵ A free Excel-based calculation tool is available upon request to the authors.