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TEAM PERFORMANCE IN REAL AND VIRTUAL WORLDS: THE PERCEIVED VALUE OF SECOND LIFE

Nathaniel J. McNeese[1], Mark S. Pfaff[2], Gerald M. Santoro[2], Michael D. McNeese[2]

Department of Psychology[1]
College of Information Sciences and Technology[2]
The Pennsylvania State University
University Park, PA

Various studies in the team cognition literature suggest the primacy of face-to-face interaction over various forms of electronically-mediated communication. Theories supporting distributed cognition and anchored perception indicate that select forms of communication media may create impoverished shared mental models that fail to transfer understanding across team members. Of particular interest in this study is the perceived value of a new virtual communication medium, *Second Life*, as compared to face-to-face or auditory teleconferencing in a team task. Team members perceived the face-to-face modality to better aid the team than *Second Life* or the auditory teleconferencing mode, yet the results show an experience-based bias toward face-to-face interaction. Team success was rated worst for the auditory condition. Discussion of these results are developed in terms of their impact on theory, practice, and applications. Additional data analyses are suggested that will yield in-depth understanding of Jasper team performance.

INTRODUCTION

This paper seeks to explore whether distributed cognition can adequately be conceived within a virtual world as compared to audio teleconferencing and face-to-face communication mediums. Owing to the recent popularity and use of the *Second Life* virtual world, and its ability to be adapted to study team performance, it is incorporated as an experimental communication medium for this research. This initial research seeks to assess users' perceived values of these mediums.

Virtual World Interaction

Virtual Worlds are simulated, immersive, multimedia environments accessed by multiple users through computer networks. Although there are many possible ways a virtual world can be engineered, they all tend to share six features: (1) shared space, (2) graphical user interface, (3) immediacy, (4) interactivity, (5) persistence, and (6) socialization/community (Book, 2006).

Similar in design to massively-multiuser online graphical role-playing games (MMORPG), virtual worlds attempt to keep some similarity to the real world, at least in terms of spatial relationships, time, and certain physical rules (such as whether objects can pass through each other). They provide naturalistic contexts in which millions of users can immerse themselves in a graphical virtual environment, assume avatars, and interact with each other (Yee, 2006).

Much like the personal computer of the late 1980s, virtual world interfaces are still primitive, have an infrastructure that is evolving, and their network bandwidth is too narrow. Nevertheless, millions of people world-wide are devoting hours to their virtual lives. This begs the question as to whether there is a real potential for virtual worlds to provide a useful medium for distributed cognition.

The Second Life Virtual Environment. According to Linden Labs (developer of *Second Life*) there are currently 12,942,144 avatars registered – with 746,301 avatars logged in during the past 30 days (Linden Labs, 2008). Many others, in business, government and education are also exploring the potential of *Second Life* as a medium for group communication. According to IBM's global director of 3D Internet and virtual business, holding a discussion in a virtual world offers the opportunity to create three-dimensional diagrams of what is being discussed (Wagner, 2007). It is clear that users are seizing upon the communication and interactive potential in virtual worlds, much as they similarly did when the early Internet/Arpanet was developed. Yet, much of the potential for virtual worlds is still based on promise.

Given the potential (and promise) there are also limitations to *Second Life*. One such limitation is the ability to implement body language. Some simple gestures are possible (wave, laugh, bow), but it requires experience and keyboard dexterity to use even these limited capabilities and there is no capability for conveying facial expression. Users have developed interesting proxies, many based on chat conventions. Although these conventions are useful they require intent, whereas real body language subtext is often unconscious.

A voice feature has been available in *Second Life* for the past year (and earlier as some users employed Skype or other services for this), but it is not reliable and was not used in this experiment. For this study, communication in the *Second Life* virtual world is limited to typed messages augmented by physical surroundings and proximity to other avatars.

The Development of Distributed Cognition

According to Jones et al. (2004) a common ground of understanding must be developed within teams before the assessment of a situation can take place. When this understanding is met within the team it is then and only then that the team becomes aware of the processes that must be completed to successfully adapt to a situation. Mediums of communication such as audio teleconferencing and virtual worlds may influence how effective these common grounds are established, and ultimately how successful teams are in completing a given task.

Previous literature in the area of distributed cognition has shown that one fundamental aspect that develops higher order cognitive processes is that of perceptual anchoring (McNeese, 2001). Perceptual anchoring can help create a shared experience of distributed cognition within a situation, and may lead to a shared mental model within teams. Perceptual anchors could provide experiential understanding either through the auditory channel (e.g. via audio-teleconferencing) and/or the visual channel (e.g. through the use of virtual worlds). Perception via audition may be less cluttered (i.e. not as much information overload) but visual expression may provide richer levels of perceptual contrasts and comparisons especially if complemented by 3D graphical representations or dynamic movements, or personalization of social networks. The *Second Life* virtual world also offers the potential of a more persistent community for problem solvers to facilitate development of shared mental models. Therein, each of the mediums in this study could develop shared mental models differently during problem solving.

A shared mental model affords the basis upon which the majority of the team shares a representation of the situation as they "see" it (Endsley & Jones, 2001). This theory of a shared mental model is one that coincides directly with the type of communication given to transfer that mental model. If the medium of communication is insufficient in its ability to transfer ideas at a steady pace among team members then a shared mental model will never have the chance to develop. For this study, the hypothesis is that performance for solving a certain problem would be greatest for teams interacting face-to-face, followed by audio teleconferencing and the virtual world *Second Life*. This hypothesis also entails that a shared mental model would be created the most efficiently within face-to-face communication and least efficiently within *Second Life*. *Second Life* was hypothesized to perform the worst because ideas could not be shared at the same pace as compared to the other communication mediums. The extra time it would take to share ideas by typing was thought to hinder the creation of an overall strong shared mental model.

METHODS

Participants

Ninety-six students from a large, northeastern university (70 male and 26 female) participated in the study. 39% were freshmen, 28% sophomores, 20% juniors, and 13% seniors. 39% were information sciences and technology majors, 25% were majoring in business, with the remainder in a range of other majors. Participants were randomly formed into 32 groups of three participants each.

Groups were randomly assigned to one of three communication mediums, face-to-face (10 teams), audio teleconferencing (10 teams), and the virtual world *Second Life* (12 teams).

Materials/Tasks

The Jasper video (*Rescue at Boones Meadow*, CTGV, 1997) was formulated as a team cognition task in this study. This task embodies problem solving by requiring participants to plan, re-plan, and engage in multifaceted decision-making within complex situations where information is loosely defined. Jasper is based on the use of a video story where participants must solve a search and rescue mission which utilizes distance, rate, and time parameters, along with flight and ground transportation information, to facilitate the rescue of an eagle trapped in an obscure location. The solution contains multiple parts, including which actors in the problem are responsible for the rescue, which methods of transportation must be used, and the total time needed to rescue the eagle.

Post-task survey measures contained multiple items on teamwork and task outcome, recorded on five-point Likert scales, as well as basic demographic items. Team interactions were all recorded in a format conducive to analyzing actual task performance at a later time through protocol analysis.

Procedure

When subjects arrived they were instructed to work together on a team problem-solving task using selected communication mediums. Once informed consent forms were collected, participants were instructed to go to separate cubicles where they would watch/listen to the Jasper video on a computer with headphones. After the video was over they were instructed as to what type of communication medium they would use to figure out the Jasper problem and given 40 minutes to complete the task. For the face-to-face condition they moved to a separate table where they could all face each other, but had a computer terminal available to refer back to the Jasper video if necessary. This interaction was video recorded. For the audio teleconferencing condition they worked on computers in separate cubicles while discussing the problem void of facial interaction. This interaction was audio recorded. For the *Second Life* condition members were instructed to view a brief tutorial as to how the virtual world worked. After the tutorial they went back to their cubicles and proceeded to figure out the problem within Second Life. The chat logs were recorded for this interaction. After 40 minutes, participants in all mediums were then instructed to report their group's solution to the Jasper problem, complete the individual post task survey, and were then dismissed.

RESULTS

Overall, there were no significant differences between conditions in task performance for any portions of the Jasper task solution. However, there was a noticeable jump in the accuracy of the group's estimation of the time to rescue the eagle when using Second Life. As the difference between the group's answer and the correct one showed a broad and non-normal distribution, a median split on this error produced two categories, "close" (within 37.5 minutes of the solution) and "wrong" (in excess of 37.5 minutes, the largest error being 594 minutes), Pearson $\chi^2(2, N = 32) = 5.00$, $p = .08$, Cramér's $V = .40$. 75% of the participants in the Second Life condition were "close," while audio teleconferencing showed 40% "close," and only 30% were "close" in the face-to-face condition. This analysis is summarized in Figure 1.

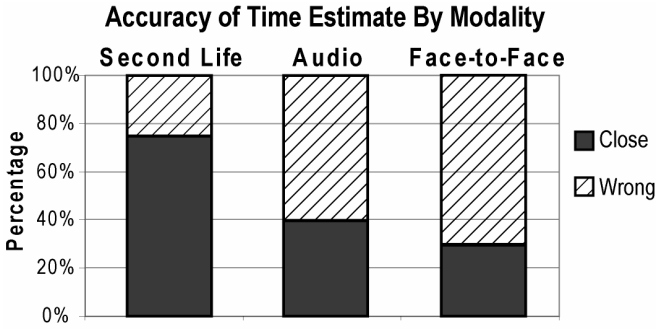

Figure 1: Comparison of close estimates of the time required to rescue the eagle by condition

Two self-report variables of particular interest were the individual's perception of the group's success ("How successful do you feel the performance of the team was?") and the degree to which the communication modality aided the group's performance ("I feel that [Second Life | teleconferencing | communicating face-to-face] aided my group in solving the problem."). Both of these variables skewed toward the high end of 5-point Likert scales and were therefore split into *high* and *low* values with *high* containing responses of 4 or 5, and *low* containing responses of 1, 2, or 3.

A two-way contingency table analysis revealed that perceived success was significantly related to condition, Pearson $\chi^2(2, N = 96) = 13.52$, $p < .01$, Cramér's $V = .38$. The proportion of those reporting high success on the Second Life, audio teleconference, and face-to-face conditions were .39, .21, and .40 respectively. Holm's sequential Bonferroni post hoc comparisons showed that the only significant pairwise difference was between the audio teleconference and face-to-face conditions. Participants were about 1.9 times (.40/.21) as likely to rate their group's performance as successful when working face-to-face rather than via audio teleconference.

Similar analysis revealed that the perception that the communication modality aided the group's performance was also significantly related to condition, Pearson $\chi^2(2, N = 96) = 42.31$, $p < .001$, Cramér's $V = .66$. The Second Life, audio teleconference, and face-to-face conditions were reported to aid the group at proportions of .18, .20, and .61 respectively. Holm's sequential post hoc comparisons showed two of the three pairwise comparisons were significantly different: Second Life and face-to-face, and audio teleconference and face-to-face. Participants were more likely to report the face-to-face condition as aiding the group's performance by a factor of 3.05 (.61/.20) over audio teleconferencing, and a factor of 3.39 (.61/.18) over Second Life. Results of both analyses are summarized in Figure 2.

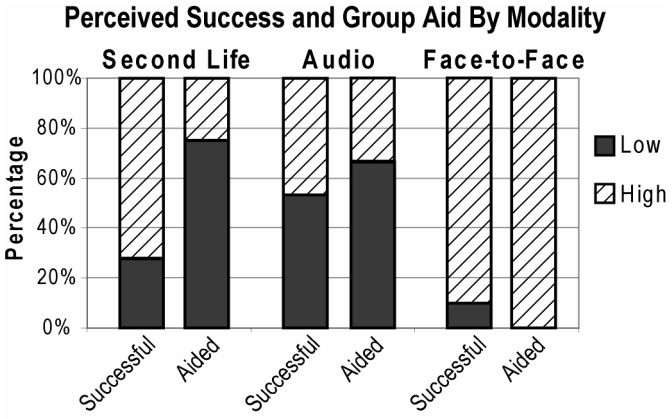

Figure 2: Analysis of respondents rating the perceived success of the group task and perceived aid provided by each communication modality.

In the Second Life condition, the perception of the virtual environment aiding the group's performance was significantly correlated with the participants' video and online gaming experience, $F(1,34) = 4.22$, $p < .05$, $R^2 = .08$.

DISCUSSION

This research shows its value by indicating that distributed cognition within a virtual environment is indeed viable. This is consistent with growing evidence that alternatives to face-to-face communication not only support effective teamwork, but in some cases may even enhance it (Wellman et al., 2000).

The reported data showing that perceived performance within *Second Life* approached the level observed with face-to-face comes as a surprise because the initial hypothesis surmised Second Life to be the least effective in performance. Teams rated their perception of success to be high with Second Life, even with communication limited to text-based chat, yet at the same time indicated that the medium was low in terms of it ability to aid the group in solving the problem. On the other hand, not only did 90% of the face-to-face participants report high success, but they unanimously agreed that face to face interaction aided the group.

This bias favoring face-to-face interaction might stem from the comparatively scarce amount of experience participants had using virtual environments. Participants who rated *Second Life* as aiding them also indicated they had strong experience with video and online gaming. This suggests that the more experience with interfaces similar to *Second Life* the more able one is to fully take advantage of the communication methods located within the medium. Therefore, one key to developing *Second Life* into a better communication tool is better training and awareness of this genre of software.

One question that must be addressed is why would *Second Life* rate higher in perceived performance than audio teleconferencing? This shows that individuals in many cases feel that visual aspects accommodate their communication more than auditory aspects. A virtual "social space" was developed during teamwork in Second Life and it showed that this "space" helped in some way to facilitate perceived performance. In open-ended feedback with participants, some commented that the graphical representation of an environment aided them because it provided a spatial network where everyone could see each other in the same room, which led many to perceive themselves as a team. This idea of a virtual "social space" is one that might explain an improved perception of success. Although the virtual "social space" helped in communication it still needs improvement to be near the same level of experience within "real space" created in face-to-face communication.

The increased accuracy in estimating the time to rescue the eagle in Second Life may be due to the written record that the text-based chat provided automatically in only that condition. A future study could explore this by adding another condition using a traditional text chat component. If the text-chat process is primarily responsible for providing this enhancement, there should be little difference in accuracy observed when using either Second Life or a standard text-chat application.

Further analysis of data collected during this study will provide an in-depth understanding of team performance on the Jasper task. In other team performance studies utilizing the Jasper task, a Problem Space Analysis (PSA), (CGTV, 1997) was used to understand the extent and level of depth of team problem solving (see McNeese, 2000; Jefferson, Ferzandi, & McNeese, 2004). Using Problem Space Analysis, the group's dialogue will be analyzed and scored on the basis of how well the group identifies, defines, and solves various interrelated elements that together compose the Jasper problem space according to their plan of attack. The Jasper task has a specified number of simple and complex problem space elements that if addressed in optimal fashion results in 100% proficiency. The PSA compares a group's obtained problem space elements to the most optimal level, hence defining their level of response in terms of percentages. This type of analysis enables a measure of team problem solving performance.

By obtaining the performance level's via PSA it will then be appropriate to compare the group's perceptual value of Second Life to the actual value that was shown

during the analysis. The data analyzed so far has shown that on a perceivable level virtual worlds are useful in forms of cognition, but in order to show that in actuality these worlds compliment distributed cognition there will need to be in-depth analysis by means of PSA on the data collected. If the PSA shows that groups did perform well on the Jasper task while in the Second Life medium then one can make a strong objective argument that distributed cognition within virtual worlds is a very tangible possibility.

One limitation in this study was perceptual anchoring was not used to its full abilities within *Second Life*. In future studies, tools could be implemented to extend the development of anchoring include developing a shared whiteboard and building a navigable model of the landscape provided to the participant in the Jasper video. By having these specific tools it would accelerate distributed cognition and lead to a stronger shared mental model. Other future studies could integrate additional technologies to complement the existing software configuration, which might include the use of voice microphones and transactive memory systems (Wegner, 1986) within Second Life. By introducing rich auditory components and memory awareness-assistance systems with already existing visual representations; communication, community and common ground could be even more expansive in Second Life.

Therefore, as the notion of the virtual world evolves, along with the underlying infrastructure and our understanding of associated ecologies of human virtual interaction, we must also explore the ways that user experience supports or detracts from useful group communication. We can then begin to look at specific issues of background, training, design and functionality to help fine-tune the effectiveness of virtual collaboration.

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