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# Examining the Effects of Mobile Robotic Telepresence Systems in Collaborative Team Dynamics

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**Abstract**

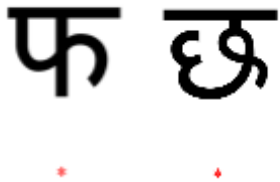
This study is currently in the data collection phase. Its purpose is to examine whether the embodiment and spatial interaction currently afforded by Mobile Robotic (Tele)presence (MRP) systems sufficiently enhance distributed team interactions or if teams still face common hurdles of remote collaboration, such as inequity of remote member interaction and participation. We propose a systematic examination of MRP group behavior and conversational analysis to address this question. We specifically highlight an ongoing lab experiment in which three-member teams (2 collocated, 1 remotely telepresent) complete a symbol translation task. Three conditions manipulate the access of task-required information among team members (shared access, restricted access to the MRP member, restricted access to local members). These conditions are intended to assess whether local members perceive and interact with a remotely telepresent member as they would with collocated others, even in conditions where task success is not functionally dependent on such interactions.

**Author Keywords**

Telepresence; Robotics; Teamwork; Groups; CSCW.

## Proposed Study Summary

**Task:** As quickly as possible, three-member teams (2 local, 1 remote via MRP system) find and translate 12 Devanagari symbols to English letters in order to solve for three, four-letter word puzzles.



**Figure 1:** Sample of Devanagari symbols in word translation puzzles.

### Conditions:

1. Only the telepresent member has access to the necessary symbol translation key.
2. Only local members have access to the translation key.
3. All members have access to the translation key

## ACM Classification Keywords

H.5.3 Group and Organization Interfaces

### Introduction

In modern organizations, geographically distributed teams, in which people must collaborate remotely, are relatively common. New organization structures have emerged that rely on distributed groups to conduct large portions of an organization's work [2] However, distributed teams and organizations may suffer in comparison to their collocated counterparts. For example, research finds scientific collaborations spanning multiple institutions are less successful than those within a single institution [4].

Some of the challenges of geographically distributed work stem from deficiencies in computer-mediated communication (CMC) tools that often lack the benefits of physical collocation [8][10][11]. Physically collocated team members use gesture [1], gaze [7] and other cues to ensure clear understanding among one another [3]. While a number of CMC tools have been developed to support remote participation in meetings and presentations, we argue that a significant gap in practical function persists. As workforces become increasingly geographically dispersed and require more remote collaboration, teams are searching for effective tools to overcome the challenge of distance.

Mobile Robotic (Tele)Presence (MRP) systems are a promising new technology for overcoming this challenge and improving organizational and team-based interactions [13][14]. MRPs consist of an audio/video conferencing system mounted on a mobile base that a remote user can move throughout a workspace [6][9]. MRPs are unique in that they support a form of remote,

physical embodiment as well as spatial interaction within a work environment previously unavailable in CMC technologies. Recent commercialization of units costing below \$2500 make "robot-mediated interaction" a viable alternative to conventional CMC for geographically distributed organizations [12]. However, it is important to understand how these tools influence team dynamics.

The purpose of this paper is to briefly summarize a study, currently in the data collection phase, that examines whether the physical embodiment and spatial interaction afforded by an MRP system is sufficient to encourage team interactions. Specifically, the proposed study seeks to address a gap in the current literature to analyze interactions among telepresent and local team members. This adds a team dynamic aspect to MRP-based research to understand how local team members may perceive and interact with telepresent members differently compared to other local members.

### Study Methodology

In order to examine team dynamics among both remote and local team members, we have designed a collaboration task wherein teams must complete a translation task. The three-member teams are comprised of two local, physically collocated members and one remote, telepresent member. The task requires team members to physically locate a set of 12 Devanagari symbols (see Figure 1 for sample symbols) distributed throughout the local space, translate the symbols to English letters using a provided translation key, and use the translations to solve for three four-letter word puzzles. Participants are tasked with solving these word puzzles as quickly as possible. The task is designed such that locating the symbols requires

members to physically navigate the space in order to leverage the robot's mobility in the task.

#### *Study Conditions*

Three conditions are manipulated to compare interactions between scenarios where team interaction with the telepresent member is either required for task success or not required. We manipulate these conditions by disseminating the required translation key to specific team members. These conditions include:

1. A condition wherein only the telepresent member has access to the translation key, necessitating collaboration with this member.
2. A condition wherein only local members have access to the translation key, removing the requirement of collaboration with the telepresent member.
3. A condition wherein all members have access to the translation, similarly removing the *requirement* of telepresent collaboration as in condition 2. However, this condition enables the telepresent member to participate in translation as needed or desired by the team.

Collectively, these three conditions represent distinct situations for the telepresent member including 1) information advantage, 2) information deficiency, and 3) information equity. Examining team interactions between these conditions should provide insight into how likely local members are to engage with telepresent members as they would other face-to-face collaborators as well as how these dynamics shift depending on how the telepresent member is situated in the collaboration.



**Figure 2:** Local participants interacting with a remote participant via the Beam+™ MRP system.

#### *Technology Specifications*

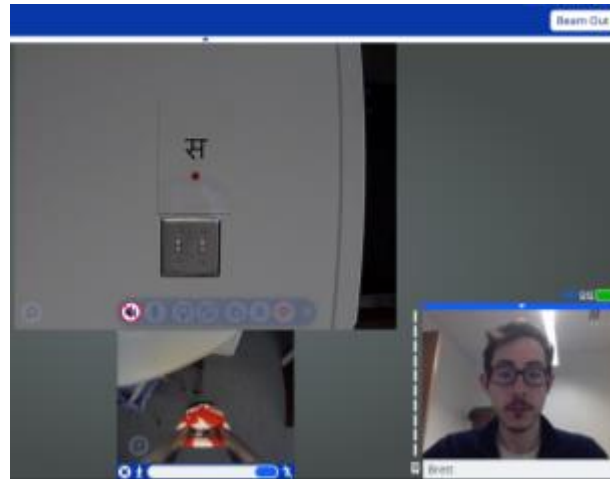
The telepresent member pilots a Beam+™ telepresence robot, a consumer model MRP system designed and produced by Suitable Technologies, Inc. The specifications for the Beam+™ robot include a 10-inch LCD flat-panel screen that displays the remote pilot via a webcam enabled by the pilot's device, two built-in 640x480 HDR cameras (one forward-facing, one downward-facing) with 30 frames-per-second video that provide the pilot with video feedback of the local environment, as well as a four-microphone array providing local audio feedback to the pilot. The Beam+™ robot can be piloted by any WiFi enabled device that supports the Beam App administered by Suitable Technologies, Inc, including mobile devices running Android or Apple IOS. For the purposes of this study, all participants operate the Beam App on a 13-inch Late 2012 MacBook Pro with Retina Display, 2.5

## Team Interaction Analysis

Coding Scheme [5]

- **Input-Seeking** - refers to any remark seeking help, feedback, or effort from others
- **Contributing** - when one engages in information sharing, providing feedback or some other knowledge to progress the interaction
- **Planning** – refers to general behaviors to organize activities and work related to the task
- **Reflection/Monitoring** - refers to comments on the group's activities and success
- **Social Interaction** – refers to any communication behavior that was not associated with the task

GHz Intel Core i5 processor, 8 GB 1600 Mhz DDR3 Memory, and Intel HD Graphics 4000 768 MB.



**Figure 3:** Beam+™ interface screenshot of pilot locating symbols within the local space.

Data are collected in two different ways. In the first, two digital cameras are situated in the local task space to capture both video and audio recordings of team interactions. The cameras are Sony Handycams DCR-XS40/L with Dolby Digital AC-3 audio recording and an effective video resolution of 410 KP. In addition to recordings collected during the task, all team members complete an individual survey asking them to reflect on the task and their perceptions of each individual team member and their performance. Surveys are completed and submitted electronically post-task via the Qualtrics online survey tool.

## Data Analysis

Upon completion of data collection, analysis will be conducted primarily using the video/audio recordings collected during study sessions. We will translate the recordings and initially code all interactions both according to the message sender and the receiver of a given interaction unit. Multiple coders will be utilized to account for perceptual differences in of intended message receivers. The second level of interaction coding will examine individual interaction units (speaking turns) according to total number directed at each team member, the length of each turn, and a coding scheme used in previous group interaction research [5]. Using this coding scheme, interaction units will be classified under one of five possible categories. These categories include:

- Input-seeking
- Contributing
- Planning
- Reflection/Monitoring
- Social Interaction

By classifying interactions in this manner, we can distinguish not only how much participants communicate with one another, but the types of communication the use with specific members. For example, local members may tend to engage in more social interaction with one another compared to with the remote member.

Survey reports of team and individual performances will be analyzed using SPSS statistical analysis software. The purpose of this analysis is to detect potential differences between conditions in how participants

perceive individual member contributions, as well as task difficulty and team effectiveness.

### **Initial Observations and Future Research Direction**

The purpose of this study is to better understand how deploying MRP systems in team collaboration affects team dynamics. Does the physical embodiment and spatial interaction afforded by these telepresence systems effectively facilitate collaboration between remote and local team members? Although data are still being collected, pre and post-task discussions with local participants has suggested some uncertainty on how best to incorporate the remote participant in the task. This was particularly evident in conditions where the remote participant does not possess an information advantage. However, how anecdotal reflections translate to interactions is yet unknown. Observed differences between how local participants interact with telepresent members compared to other local members may indicate a need to further consider how these systems are designed and what additional features may be necessary to improve interactions.

Subsequent studies in this research project will examine how the presence of multiple MRP units influences team dynamics. It is equally important to consider the effect of teams incorporating a single, or minority, telepresent membership as well as teams wherein the majority membership may be robotically telepresent. Additionally, future research should consider how team members make attributions about remote members according to both the characteristics of the robotic tool as well as the person controlling it.

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